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USER'S GUIDE FOR THE AERMOD METEOROLOGICAL PREPROCESSOR (AERMET)

U.S. ENVIRONMENTAL PROTECTION AGENCY
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PREFACE

AERMET provides a general purpose meteorological preprocessor for organizing available meteorological data into a format suitable for use by the AERMOD air quality dispersion model. AERMET is designed as a three stage system. This user's guide provides instructions for setting up and running the AERMET preprocessor. National Weather Service (NWS) hourly surface observations, NWS twice-daily upper air soundings and data from an on-site meteorological measurement program can be processed in AERMET. There are three stages to processing the data. The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks. The second stage merges all data available for 24-hour periods (NWS and on-site data) and stores these data together in a single file. The third stage reads the merged meteorological data and estimates the necessary dispersion parameters for use by AERMOD. Two files are written for AERMOD: hourly dispersion parameter estimates and a file of multiple-level observations of wind speed and direction, temperature, and standard deviation of the fluctuating components of the wind.

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SECTION 1

INTRODUCTION

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS), is developing a new air quality dispersion model, the AMS/EPA Regulatory Model (AERMOD). This model requires a preprocessor that organizes meteorological data from National Weather Service (NWS) upper air and hourly surface observations stations and multi-level, on-site observations, and estimates the necessary parameters for dispersion calculations. The meteorological preprocessor that serves this purpose is AERMET, which is based on the Meteorological Processor for Regulatory Models (MPRM) (Irwin, *et al*, 1988) and METPRO (Paine, 1987), the meteorological preprocessor for the complex terrain dispersion model CTDMPLUS. Currently, AERMET only preprocesses data for AERMOD. However, its modular design and flexible interface allows for the addition of parameter estimates for other air quality models, present or future.

1.1 OVERVIEW OF AERMET

AERMET is designed to be run as a three-stage process. The first stage retrieves data from the various sources of data -- upper air and surface data provided by the National Weather Service and available from the National Climatic Data Center (NCDC), and data gathered under an on-site measurement program using an instrumented tower, remote sensing instrumentation or a combination of both. The retrieved data are processed through a set of quality assessment (QA) checks that report the presence of missing and out of range values, as well as inconsistencies among variables within each observation period. The second stage combines (merges) the available data for each midnight-to-midnight, 24-hour period and writes these data to an intermediate file. The third and final stage reads the merged data file and develops the necessary dispersion parameters for a dispersion model.

1.1.1 Stage 1 - Extraction and Quality Assessment

For NWS data, this stage reads archived meteorological data files, retrieves those data for a specified location and within a specified time interval, and writes the extracted data to formatted ASCII files. This process is referred to as extracting data. It reads the extracted data and checks the validity of the specified variables, reporting those that are missing or outside a range of values. The data are written to a second set of formatted ASCII files. On-site meteorological data only require the QA step because the data are assumed to be available in an ASCII file on disk and not in a standard archive data format.

AERMET processes several standard data formats. These include the TD-6201 format for upper air sounding data, the CD-144 format for hourly surface weather observations, which is a time-based (i.e., by hour) format, and the TD-3280 format, which is an element-based (i.e., by variable) format for surface data. These formats are all available from NCDC. AERMET also processes the hourly surface data format available from the EPA's Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN) electronic bulletin board. This format is a reduced form (fewer variables) of CD-144 files that are available from the Support Center for Regulatory Air Models (SCRAM) section of the TTN.

There is no standard format or content for on-site meteorological data. The data collected on-site most likely will include observations made at several levels on an instrumented tower or from remote sensing instrumentation. Additionally, single-valued measurements such as net radiation and the surface weather variables found in the NWS format may be included. AERMET is designed to accept a variety of on-site data formats by having the user specify the structure of the data. However, the data must be in an ASCII file and able to be read with standard Fortran format statements. Additional restrictions and specification of on-site data is discussed in more detail in Sections 2 and 3.

Quality assessment is performed for all the data types. The QA process reports occurrences of missing data and values that are outside a range of values. It can also check for inconsistences between some variables within an observation period. There are default values defined for the upper and lower bounds and for missing values, which can be modified by the user through the runstream file that controls preprocessor actions. Some variables are checked by default (as noted in the tables in Appendix B) and the user can specify additional variables to be checked. Missing data or data that violate one of the bounds are not changed during the QA process.

The extracted and QA'd output files can be edited using standard text editors. This allows the user to modify/correct those values that were identified by the QA process as possibly in error. However, any modifications should be based on sound meteorological principles and comply with any relevant regulatory guidance. A word of warning: these files can be very large and easily exceed the size limitations of older text editors.

1.1.2 Stage 2 - Merging Data

This stage of the processing combines the separate quality assessed files into a single ASCII file. This file is organized so that each block of data contains all of the observations for a 24-hour period. This period begins with hour 1, representing the period from 0001 local standard time (LST) to 0100 LST, and ends with hour 24, representing 2301 LST to 2400 LST. Any program reading a merged block of data will have one full day of data available for processing. If any input data to this stage of processing are physically missing for the hour (e.g., down-time for instrument maintenance), then the values for that hour are represented by the appropriate missing value indicators (as shown in the tables in Appendix B).

1.1.3 Stage 3 - Creating Model Input Files

This is the final stage of processing that reads the merged file and, in conjunction with site-specific characteristics that describe the underlying surface, produces two input files for AERMOD: single-valued data and profile data. The single-valued file contains scaling parameters (such as surface friction velocity, mixing height, and Monin-Obukhov length) and reference-height winds and temperature. The file of profile data contains one or more levels of winds, temperature and the standard deviation of the fluctuating components of the wind. Generally, this latter file contains data from an on-site measurement program. In the absence of such data, a single level using NWS hourly surface observations is used for the profile.

Presently, AERMET only creates meteorological input files for AERMOD. However, AERMET's flexibility can allow for future expansion to create input files for other dispersion models requiring other algorithms and output formats.

1.1.4 General File Structure

All the output files through Stage 2 have a similar structure. The output file begins with header records followed by the data records. The header records are the records from the input runstream file echoed to the output file. An asterisk appears at the beginning of each header record in an output file. The asterisk has no other purpose than to identify the record as a header. Some of the header records have special (ASCII) characters after the asterisk to allow AERMET to reprocess these records in subsequent steps. This procedure frees the user from specifying the same information in subsequent runs and provides consistency from stage to stage. For example, the format of the on-site data can be specified only once in a runstream file because the statements that define the format are retained and reprocessed in subsequent AERMET runs. It is important that the user not change any of the header records, otherwise the data could be processed in an undesirable way or cause AERMET to fail with an undetermined error.

The processed data appear after the header records. The format of these data can be found in Appendix C. For the NWS surface and upper air data, the data have been "integerized", i.e., the value is written as an integer. To retain significant digits for some of the variables, such as temperature and wind speed, the values are multiplied by 10 or 100 before writing the value. The process is reversed when the data are needed for parameter estimates. With a nonstandard format and content, the on-site data are written with the same input format specified by the user in the runstream file.

1.2 BASIC HARDWARE REQUIREMENTS

The desktop personal computer (PC) has become a very popular platform for dispersion model applications. As such, AERMET is designed to be run primarily on IBM-compatible personal computers with an 80386, or equivalent, central processor.

The current version of AERMET was developed on an IBM-compatible PC using the Lahey™ F77L-EM/32 Fortran compiler (version 5.2). The source code and two executable programs require approximately 2.5 Mb of disk space. A math coprocessor is mandatory for use of the Lahey-compiled executables. For AERMET to process one year of data through Stage 3 (using NWS and on-site data) requires about 45 seconds on a 90 MHz Pentium with 24 Mb of RAM. On a 33 MHz 80486 PC with 4 Mb of RAM, nearly 2.5 minutes is required to perform the same calculations. The amount of space required by the data files varies according to the type of data. File sizes range from 0.5 Mb (for one year of upper air soundings) to 6 Mb for a merged data file with all possible data types. Output file sizes for the individual files are given in Section 3.

1.3 DOCUMENT OVERVIEW

In Section 2, the basic requirements to run AERMET are discussed in the form of a tutorial. The keyword approach and basic rules for constructing the input control files are discussed for each data type. The use of the AERMET system reports to review the processing is discussed. Section 3 discusses all the keywords in more detail, many of which were not used in the tutorial. Section 4 presents a more detailed discussion of the error and message files. Section 5 discusses the technical basis for the parameter estimates in the final stage of processing. Section 6 discusses various hardware and software aspects of the preprocessor.

Appendices A through D collectively form a reference guide for running AERMET. Appendix A describes the control file statements, while Appendix B describes the input variables and their default bounds and missing values codes. Appendix C describes the format and content of the AERMET input and output files. Appendix D describes the various error messages that may be generated by AERMET and suggests why the error message was generated. Appendix E discusses processing data archived on magnetic tape. Appendix F discusses possible future enhancements to the preprocessor.

SECTION 2

TUTORIAL

This section provides a tutorial for setting up a simple application of each of the three processing stages outlined in Section 1. These examples illustrate the keyword approach to defining the actions to be performed and the basic requirements to prepare and process the data. A more complete description of the available keywords, including those not covered in this tutorial, is provided in Section 3. The AERMET system reports are discussed briefly here with a more detailed discussion presented in Section 4.

Processing meteorological data with the AERMET preprocessor can be divided into three primary steps, or stages. Two executable programs perform the three stages of processing. The first program, STAGE1N2.EXE, is used to extract/QA the data (Stage 1) and then merge the data into 24-hr periods (Stage 2) in a single file. STAGE3.EXE uses the merged data to produce the input files for the user-defined dispersion model. Whenever one of these programs is run, a file containing a sequence of control statements is used to define the actions the preprocessor is to perform. This file is referred to as the input runstream file, or simply runstream.

2.1 AERMET COMMAND LANGUAGE

The statements in a runstream file are divided into six functional groups, or pathways, which are:

- o JOB - for specifying information pertaining to the entire run;
- o UPPERAIR - for processing NWS upper air sounding data;
- o SURFACE - for processing NWS surface observations;

- o ONSITE - for processing user-supplied on-site meteorological data;
- o MERGE - for combining (merging) available meteorological data;
- o METPREP - for preparing estimates of dispersion parameters for the user-defined dispersion model.

The pathway identifier appears on a line by itself and signals the beginning of a contiguous block of statements that apply only to that pathway. There are two to five pathways specified in a runstream, depending on the stage being processed and the number of pathways being processed in one run of AERMET.

The statements within a pathway make use of a keyword and parameter approach for specifying the input to and actions by AERMET. The keywords and parameters that make up this file can be thought of as a command language through which the user communicates with the preprocessor. Each record in a runstream is referred to as a *keyword statement* and is composed of a keyword followed by a parameter list. The keyword specifies the nature of an action or type of option and any parameters that follow provide additional information for the action or option. For a few keywords, though, there is no parameter list, i.e., the keyword specifies the action completely. Some keywords are common to several pathways, with the function of the keyword similar across the different pathways. It is the combinations of keyword statements, particularly those that identify the input and output files, that inform AERMET how to process the data.

2.1.1 Basic Rules for Structuring an Input Runstream File

While the input runstream file has been designed to provide the user with flexibility in structuring the file, there are some basic syntax rules that must be followed. These rules enable the preprocessor to understand what the user wants to accomplish for a particular run.

A basic rule for all input files is that the pathway identifier appears on a line by itself, indicating the beginning of a sequence of keyword statements for that pathway, and all the statements for the pathway must be contiguous. In other words, all the statements for one pathway must appear together without any intervening keyword statements for other pathways.

Each keyword statement can be up to 80 characters in length and must begin with a keyword. Each field on the keyword statement must be separated by a one or more spaces or a comma and in a particular order (with a few exceptions). The keyword can begin in any column, so long as the entire length of the statement does not exceed 80 characters. Thus, keyword statements can be indented for readability, as is done throughout this user's guide.

Asterisks can appear in columns 1 and 2 (**) to inform the preprocessor to ignore the statement. By using the asterisks, the statements act as comment statements, which could be used to identify the purpose of the runstream file or to clarify the content of an individual keyword statement or to simply ignore an action or option defined by the keyword statement. Blank records can be included in the runstream to improve readability.

Alphabetical characters can appear in either upper or lower case letters. AERMET converts these characters to upper case internally (which is why any information echoed to an output file is all upper case) to insure exact matches within the programs on keywords and other critical parameters. Throughout this document, the convention of using upper case letters will be followed.

Certain keyword statements are mandatory, while others are optional. Optional keyword statements are used to include or extend certain data processing actions. Some keywords are repeatable, such as the keywords to specify the format of any on-site data, while others may only appear once. These terms are discussed in more detail in Section 3. Most of the keywords used in this tutorial are mandatory. Appendix A provides a list of keywords by pathway and identifies each as mandatory or optional, repeatable or nonrepeatable.

The order of keyword statements within a pathway is not important, except for a few keywords for the on-site data. These keywords pertain to the variables and format of the on-site data and site-specific surface characteristics.

A summary of all of the keyword statements for each pathway is presented in two appendices. Appendix A lists the keyword statements by pathway with an accompanying definition, and Appendix B describes the syntax of each statement. These two appendices form a complete reference guide regarding the function, placement, and syntax of each keyword statement.

A text editor should be used to create the necessary runstream files as ASCII files. Word-processing editors (e.g., WordPerfect) can be used, but the file must be saved as a "non-document" file, i.e., without special format control characters that are included when the file is saved in its native format. Saving the file in the word-processor's native format will introduce characters that cannot be interpreted by AERMET.

The tutorial is organized around the three stages of processing. The different pathways are discussed within each stage.

2.2 LET THE PROCESSING BEGIN

This tutorial leads the user through the processes necessary to generate the input data files for the AERMOD dispersion model. The process includes retrieving data from archive files, quality assessment of the data, combining data into one file for the final stage of processing, and generating input files for AERMOD. Data for the month of March are used for this tutorial and include observations from NWS upper air soundings, NWS hourly surface data files and user-supplied on-site data. This process is divided into the several steps, each requiring a separate runstream that a user is likely to follow to produce the input files for AERMOD. These examples show the basic requirements for each stage for all the data types. A subset of keyword statements for the six pathways are used. The function and purpose of each statement are described in the context of the desired processing.

A word of caution for this tutorial and for all AERMET runs: all output files are opened with STATUS = 'UNKNOWN'. With this specifier, an existing file will be overwritten without any opportunity to save it.

The extraction and QA can be performed as two separate AERMET runs, but for purposes of this tutorial, the two processes are combined into one run. At the end of the appropriate sections, a table indicates which keywords perform these two processes as separate runs.

2.2.1 Stage 1 - Extraction and Quality Assessment

Stage 1 comprises both the extraction/retrieval of data from archived data and the processing of the data through a series of quality assessment (QA) checks. Data extraction is generally a one-time activity, while the assessment of data quality may be performed several times on progressive versions of the extracted data file (versions where the user has corrected errors in the data). The QA identifies missing and "suspect" data values. Once the user determines how such values are to be treated, a text editor can be used to modify the data if necessary. At present, there are no provisions in AERMET to automatically replace missing data or correct "suspect" values. Any changes must be performed manually by the user and should be based on meteorological principles and comply with any relevant regulatory guidelines.

Modifications should only be done on extracted data, and not on the archive file. The archived data should never be altered, but should be maintained as delivered. Whenever modifications are made, the modified data should be reprocessed through the QA process of Stage 1. This stepwise procedure may identify new problems that, in turn, need to be addressed.

When the user is satisfied that the quality of the extracted data cannot be improved further, the data are ready for the next stage (merging data).

2.2.1.1 JOB Pathway

The JOB pathway is common to all preprocessor runs and may appear anywhere in the runstream file, but it usually appears first. The basic keywords associated with this pathway are:

ERRORS - specifies the filename where all the errors, warning and informational messages generated by AERMET are written; a mandatory keyword;

REPORT - specifies the filename where the general summary report of the run is written; an optional, but highly recommended, keyword.

The JOB pathway statement appears on a line by itself, followed by the statements with the ERRORS and REPORT keywords. All the examples in this user's guide open with this block of statements (although the file names will be different in each example). Refer to any of the figures in this section with a runstream for an example of the JOB pathway.

There are nearly 100 different messages regarding the runstream and data processing that AERMET can write to the file defined by the ERRORS keyword. Appendix E contains a list of these messages with a brief explanation of each. Depending on the pathways and keywords defined in a particular run, this file may be rather long, so it is advisable to check the size or view it prior to printing it. The REPORT keyword is not mandatory, but is usually specified. If the REPORT file is not specified, the summary is written to the default output device, e.g., the screen on a personal computer, which can be captured using redirection (discussed later in this section). Both files contain information that can be used to determine if a particular run was successful or failed, and if the run failed, give the reason(s). A brief discussion of the content of ERRORS and REPORT files is at the end of this section, with a more detailed discussion in Section 4.

One other keyword is associated with the JOB pathway:

SYNTAX - checks the syntax of the runstream file for errors, without processing any data.

A synopsis of all the keywords available on the JOB pathway can be found in Appendices A and B.

2.2.1.2 SURFACE pathway

AERMET can extract archived data from three different surface data formats. For application on a personal computer, AERMET can process the CD-144 format that is available from the National Climatic Data Center (NCDC) and the SCRAM format, which is a reduced form (fewer variables) of the CD-144 format available from OAQPS' TTN bulletin board. The CD-144 format represents a previous generation format standard for hourly surface observations. In its simplest form, one record contains all the weather elements for one hour. AERMET also supports the current standard format, TD-3280, which is an element-based format, i.e., the data are archived by weather element rather than by hour. This latter format is best supplied on magnetic tape. The format supplied on diskette for personal computers does not lend itself to processing on a PC without major modifications to AERMET. Processing data on magnetic tape is discussed in Appendix F.

The basic keywords used to extract and assess the quality of NWS surface data are:

DATA - specifies the input file name of the archived data and the file format for the extraction process;

EXTRACT - specifies the output file name of extracted data/input file name for the QA;

XDATES - specifies the period of time to be retrieved from the archived data file;

LOCATION - specifies the station identifier, latitude and longitude and the factor to convert the time of each data record to local standard time;

QAOUT - specifies the output file name from the QA process/input file name to Stage 2.

To perform this dual action (extract and QA) in a single run, all of the above keywords are mandatory. The order of these keywords within the SURFACE block is not important.

An example runstream to extract and QA hourly NWS surface observations is shown in Figure 2.1. The runstream file begins with the JOB pathway, as discussed previously, writing messages to SFCERR.LIS and the run summary to SFCRPT.LIS. The SURFACE statement indicates that a block of keyword statements for the SURFACE pathway are to follow. The presence of both the DATA and EXTRACT keyword statements informs AERMET that data are to be extracted (retrieved) from a file of archived data. The DATA statement identifies the name of the archived data file (S1473588.DAT) as well as the file format, CD144FB. The format refers to the CD-144 format from NCDC and the FB refers to fixed-length blocked records in which each logical record is the same length. The EXTRACT statement specifies the file in which the extracted data are written. It is a standard ASCII file. The general format of the output files (header records followed by data records) is discussed in Section 1, and Appendix C provides information on the specific structure for NWS hourly surface observations.

```
JOB
  ERRORS    SFCERR.LIS
  REPORT    SFCRPT.LIS

SURFACE
  DATA            S1473588.DAT   CD144FB   1
  EXTRACT   SFCEXT.DSK
  XDATES    88/3/1  TO  88/03/10
  LOCATION  14735  42.75N  73.9W  0
  QA        SFCQA.DSK
```

Figure 2.1. Example Runstream to Extract and QA NWS Surface Data in CD-144 Format.

XDATES identifies the inclusive dates, in the form YY/MM/DD, of the data to be retrieved, where YY is the year, MM is the month and DD is the day, all specified as integers. The word "TO" is optional and is ignored during the processing of this keyword statement, but makes this keyword statement a little more understandable. Notice that the month and day can be specified with or without leading zeros. In this example, NWS hourly surface observations for the period March 1, 1988 through March 10, 1988, inclusive, are extracted from the archive file.

If the XDATES statement is omitted, then AERMET writes an error message indicating that the XDATES keyword statement had errors (in this case it would be missing altogether!) and stops processing the hourly surface observations. The reason the period of time must be specified is that data on a magnetic tape may contain multiple years (as well as multiple stations), and to extract all data for a particular station could produce an extremely large file.

CD-144 data received from NCDC on diskette and the hourly observations retrieved from SCRAM are generally composed of just one station's data. However, if data are extracted from magnetic tape, then there is usually more than one station's data on the tape. In either case, the LOCATION keyword is required and specifies the station identifier for which data are to be extracted. In this example, 14735 is a Weather Bureau Army Navy (WBAN) number (discussed in Section 3) for Peoria, Illinois. The NWS station latitude and longitude are specified in decimal degrees. These coordinates can be specified in either order, but the directional specifiers (N and W in this case) are required. AERMET does not recognize "+" and "-" to distinguish between north/south and east/west. The LOCATION keyword also defines the number of hours required to convert the time of each data record to local standard time (LST). Since most formats reporting hourly surface observations use local standard time, the conversion is usually 0, which is the default value. Therefore, this value can be omitted if the adjustment is zero. The adjustment to LST must be specified for nonzero values because time zones follow irregular political boundaries, making it impossible to automate the procedure.

The presence of both the EXTRACT and QAOUT keyword statements is the only signal to AERMET to perform the quality assessment. The QAOUT keyword identifies the file where the data that have undergone the quality assessment are written. Several variables are checked (audited) by default. These are the total and opaque sky cover, station pressure, dry bulb temperature, and wind speed and direction. During the quality assessment process, audited variables are checked as being missing or outside a range of acceptable values defined in Appendix C, Table C.2. A violation of the range or a missing value is reported in the error/message file, SFCERR.LIS. The variable name, value, upper or lower bound (depending on the violation) or missing value indicator, and date/time are reported in this file. The total number of violations and missing values are summarized in the REPORT file, SFCRPT.LIS. The user should review the error/message file to determine if the violations are true errors (e.g., a temperature of 100 °C) and need correction or if they can be ignored (e.g., a temperature that is 0.1 °C higher than an upper bound of 35 °C).

The hourly surface data are written to the output file as integers, with some variables multiplied by 10 or 100 to retain significant digits. The value and bound or missing indicator is multiplied by the same factor. The data values in the message file retain this "integerization" and should be kept in mind when reviewing the results of the QA.

The AERMET preprocessor does not make changes to the data during the QA process. If the quality assessment identifies any problems, then either the EXTRACT file (SFCEXT.DSK) or the QA file (SFCQA.DSK) may be edited to manually correct the offending data in accordance with sound meteorological principles and within any relevant regulatory guidelines. If the modifications are extensive, it is recommended that the data be reprocessed through the QA to catch any problems introduced with the modifications. However, if the QA output file is used as input to another QA run, remember to use a new output file name.

The output file from the QA process is identical to the input file, except for the addition of a header record. The preprocessor reads the hourly data and writes the same data to the output file. One may question the existence of the QA output file since the data are a copy of the EXTRACT output file. The answer is that this method will allow for future accommodation of automatic replacement procedures for missing values, if such procedures are established. By having the two files (EXTRACT and QA), the AERMET system has a logical design for assessing the data, reporting suspect or missing values, and storing the new or modified values.

As noted earlier, the extraction process and QA procedures can be performed separately. The necessary SURFACE keywords required in the input runstream files to perform each separately are:

extraction	quality assessment
DATA	
EXTRACT	EXTRACT
XDATES	
LOCATION	
	QAOUT

Of course, the block of statements for the JOB pathway must be included in both runstream files. An example of these processes alone is shown in Figures 2.2a and 2.2b. In Figure 2.2b, the asterisks in front of the LOCATION keyword statement, which force AERMET to ignore the statement, are used as a reminder as to which station's data are being QA'd.

There are several additional keywords for the SURFACE pathway that are optional:

AUDIT - adds variables to the list of default variables to be tracked during QA;

RANGE - modifies the default lower and upper QA bounds and missing value indicator for the variable specified;

NO_MISSING - specifies those variables being tracked (audited) for the QA to not report occurrences of missing values; this keyword is useful in reducing the size of the error/message file if an audited variable is missing most of the time.

A detailed discussion of each of the keywords on the SURFACE pathway is provided in Section 3, with a synopsis of each keyword in the appendices.

```
JOB
  REPORT    SFCRPTEX.LIS
  ERRORS    SFCERREX.LIS

SURFACE
  DATA            S1473588.DAT    CD144FB   1
  EXTRACT   SFCEXT.DSK
  XDATES    84/3/1  TO  84/3/31
  LOCATION  14735 42.75N 73.9W 0
```

Figure 2.2a. Example Runstream to Extract NWS Surface Data.

```
JOB
  REPORT    SFCRPTQA.LIS
  ERRORS    SFCERRQA.LIS

SURFACE
  EXTRACT   SFCEXT.DSK
**LOCATION  14735 42.75N 73.9W 0
  QA        SFCQA.DSK
```

Figure 2.2b. Example Runstream to Repeat QA NWS Surface Data.

2.2.1.3 UPPERAIR Pathway

AERMET can extract archived data from one NWS upper air format - the standard TD-6201 format available from NCDC. When provided on diskette, these data are always fixed-length blocks. For data on magnetic tape, the data are usually provided as variable-length blocks to conserve space, although the user can request fixed-length blocks.

The extraction and quality assessment of NWS upper air sounding data is very similar to that of NWS surface data, and uses the same basic keywords plus one additional keyword. As with the SURFACE pathway, the extraction and QA can be performed as two separate steps, but for purposes of this tutorial, the two actions are combined into one step. The basic keywords to extract and assess the quality of NWS upper air data are:

DATA -	specifies the input file name of the archived data and the file format for the extraction process;
EXTRACT -	specifies the output file name of extracted data/input file name for the QA;
XDATES -	specifies the period of time to be retrieved from the archived data file;
LOCATION -	specifies the station identifier, latitude and longitude and the factor to convert the time of each data record to local standard time;
QAOUT -	specifies the output file name from the QA process/input file name to Stage 2;
AUDIT -	specifies the sounding variables to be QA'd; note that this keyword is optional and that <u>no variables</u> are automatically QA'd on the UPPERAIR pathway; if this keyword is omitted, there will be no report for the upper air soundings.

All but the AUDIT keyword are mandatory to extract and QA upper air data. The order of these keywords within the UPPERAIR block is not important. Much of the general discussion that accompanies the SURFACE pathway also applies to the UPPERAIR pathway.

```
JOB
  REPORT    UARPT.LIS
  ERRORS    UAERR.LIS

UPPERAIR
  DATA            14735-88.UA  6201FB  1
  EXTRACT   UPAIREXT.DSK
  XDATES    88/3/1  TO  88/3/10
  LOCATION  00014735  73.8W  42.75N  5

  QA        UPAIRQA.DSK
  AUDIT     UATT UATD UALR
```

Figure 2.3. Example Runstream to Extract and QA NWS Upper Air Sounding Data in TD-6201 Format.

Figure 2.3 shows an example that extracts and QAs upper air soundings. The runstream file begins with the JOB pathway, writing messages to UAERR.LIS and the summary of the run to UARPT.LIS. The UPPERAIR statement indicates that a block of statements for the UPPERAIR pathway are to follow. The presence of the DATA and EXTRACT keyword statements informs AERMET that data are to be extracted from an archive data file named 14735-88.UA. The data are in the TD-6201 fixed-block format, as specified by the format field 6201FB. The "1" after the format indicates that there is one logical record per physical record in the file. For data on a diskette, there is one logical record (i.e., sounding) per physical record. However, archive files on magnetic tape may contain more than one logical record per physical record as a space-saving measure.

The EXTRACT keyword statement specifies the file in which the extracted data are written. It is a standard ASCII file; the format of the data in this file is given in Appendix D.

XDATES identifies the inclusive dates, in the form YY/MM/DD, of the data to be retrieved. YY is the year, MM is the month and DD is the day, all specified as integers. The word "TO" is optional and is ignored during the processing of this keyword statement. In this example, data for the period March 1, 1988 through March 10, 1988, inclusive, are extracted from the archive file.

The LOCATION keyword specifies the station identifier for which data are to be extracted. In this example, 00014735 is a WBAN number. Unlike the surface pathway, the identifier requires leading zeros because the field in the archive file contains leading zeroes. The entire field is read from the archive file as a character variable. Hence, for AERMET to match the station identifier in the archive file with the identifier in the runstream, the leading zeroes are required. The NWS station latitude and longitude are specified in decimal degrees. These coordinates can be specified in either order, but the directional specifiers (N and W in this case) are required. AERMET does not use, nor recognize, "+" and "-" to distinguish between north/south and east/west. The LOCATION keyword also defines the number of hours required to convert the time of each data record to local standard time. A positive value indicates that the station is <u>west</u> of Greenwich. This value is subtracted from GMT to obtain LST. Normally, the soundings are reported for 0000 GMT and 1200 GMT. Therefore, to convert the time to eastern standard time (the time zone for 73.8 west longitude), AERMET subtracts the last parameter on this keyword statement from GMT to get LST. In this case, the adjustment is five. For a sounding date in the archive file, this adjustment yields 1900 LST <u>of the previous day</u> for the first sounding of the day and 0700 LST for the second sounding in the extracted file. The reason for performing this operation is to insure that all data for the current day are properly specified for the Stage 2 merging process.

A word of caution is in order at this point. The NWS has modified the method of reporting time in upper air sounding data. Prior to about 1990 twice-daily soundings were always reported for 0000 GMT and 1200 GMT, rather than the time the sounding was released. Current practice is to report the actual release time. For example, a rawinsonde launched at 1122 GMT (0622 Eastern standard time) is now reported as 1122 GMT rather than 1200 GMT as it would have been reported in the past. This variability makes the data manipulation less certain. Therefore, when AERMET makes dispersion parameter estimates (Stage 3), the preprocessor looks for a window of time (± 1 hour) for the morning sounding. If by chance the preprocessor fails to locate a morning sounding during Stage 3 processing, it is possibly due to a launch time outside the 1100-1300 LST window. Unfortunately, when this situation occurs the convective mixing heights cannot be computed for the entire day and a message is written to the message file. If the user encounters this message, the upper air data for that day should be reviewed to determine if the data are missing or at a time outside the search window. The only corrective procedure for the latter condition at this time is to change the time of the sounding in the data file (the output from the QA is suggested) to be in the search window and rerun Stages 2 and 3.

The sounding heights on NWS upper air files are stored as meters above mean sea level. When the upper air soundings are extracted, the heights are converted to meters above ground level. The first level in a sounding in the TD-6201 format is always for the surface. The height at this level is subtracted from all levels including the surface, so that the heights start at 0 meters. The surface height is not retained for use in any subsequent soundings; therefore, in the event that the surface height is missing in a sounding, a value of zero is assumed in performing the adjustments.

The presence of both the EXTRACT and QAOUT keyword statements is the only signal to AERMET to perform the quality assessment on upper air data. The QAOUT keyword identifies the file where the data that have passed through the quality assessment are written. There are no variables checked (audited) by default. To QA any of the upper air variables, the AUDIT keyword must be used. The variable names, as shown in Table C.1, are specified on this statement. In this example, the temperature (UATT), dew point temperature (UATD) and lapse rate (UALR) are checked. While the temperature and dew point are in the file of extracted data, the lapse rate is computed during the QA and discarded (i.e., the lapse rate is not saved in the output file). The lapse rate can alert the knowledgeable user to unusual, but possibly valid, variations in the temperature structure of the atmosphere.

During the quality assessment process, audited variables are checked as being missing or outside a range of acceptable values defined in Table C.1. A violation of the range or a missing value is reported in the message file, UAERR.LIS. The variable name, value, upper or lower bound (depending on the violation) or missing value indicator, and date/time are reported in this file. Note that both the value and bound or missing indicator may be multiplied by a factor to integerize and retain significant digits (as with the data on the SURFACE pathway). The user should review the message file to determine if the violations are errors in the data and need correction or if they can be ignored. Additionally, the total number of violations and missing values are summarized in the REPORT file, UARPT.LIS. The summary of violations and missing data are divided into height thickness groups because the height at which atmospheric data are reported varies from sounding to sounding. This report will be discussed in more detail in Section 4.

If the quality assessment identifies any problems, then either the EXTRACT file (UPAIREXT.DSK) or the QAOUT file (UPAIRQA.DSK) may be edited to manually correct the offending data in accordance with sound meteorological principles and within any relevant regulatory guidelines. If the modifications are extensive, the data should be reprocessed through the quality assessment procedures to catch any problems that may be introduced with the modifications.

As noted earlier, the extraction process and QA procedures can be performed separately. The necessary UPPERAIR keywords required in the input runstream files to perform each separately are:

extraction	quality assessment
DATA	
EXTRACT	EXTRACT
XDATES	
LOCATION	
	QAOUT
	AUDIT

The block of statements for the JOB pathway must be included in both runstream files. An example of the QA process alone is shown in Figure 2.4.

```
JOB
  REPORT    UARPTQA.LIS
  ERRORS    UAERRQA.LIS

UPPERAIR
  EXTRACT   UPAIREXT.DSK
  QA        UPAIRQA.DSK
  AUDIT     UATT UATD UALR
```

Figure 2.4. Example Runstream to QA NWS Upper Air Sounding Data.

There are several optional keywords available for the UPPERAIR pathway. These are:

CEILING - specifies the maximum height (in meters above mean sea level) for retrieving upper air sounding data; the default value is 5000 meters; the maximum number of levels that can be extracted is 30, and is set by the parameter UAML in MASTER.INC;

RANGE - modifies the default QA bounds and missing value indicator for the variable specified;

NO_MISSING - specifies those variables being tracked (audited) for the QA to not report occurrences of missing values; this keyword is useful in reducing the size of the error/message file if an audited variable is missing most of the time.

MODIFY - informs AERMET to perform automatic modifications to the upper air data as the data are extracted; these modifications are described in Section 3 with the discussion of this keyword.

A detailed discussion of each of the keywords on the UPPERAIR pathway is provided in Section 3, with a synopsis of each in the appendices.

2.2.1.4 ONSITE Pathway

On-site data do not comply with any standard archived data format or content, placing the format of the data completely under the control of the user. Therefore, the extraction step is unnecessary and the data can be QA'd immediately. The data are assumed to be from one or more levels of an instrumented tower, a remote sensor (e.g. sodar), or a combination of the two, and possibly with additional near-surface data, such as net radiation. Any problems that are discovered during the QA can be corrected in the input file to the QA (making sure there is a backup of the original data file).

Without a standard content or a standard format, the user must describe the file for AERMET. AERMET "remembers" this information by storing it in the output file's header records (as described in Section 1), so the format information need not be specified again for any additional processing (repeating the QA, merging data, and estimating dispersion parameters). The format of the on-site data is reasonably flexible, subject to the following rules:

(1) The data for one observation period can be spread across several records, and the records for the period must be contiguous;

(2) The same set of variables must appear for all observation periods;

(3) The date and time information for each observation must be contained in the first record of the group; these may occur in any order within the first record, and must be integer format; on-site variables can appear on the first record after the date/time group;

(4) The variables present within each observation must be a subset of those listed in Appendix C, Table C.3a and Table C.3b;

(5) All scalar variables must precede any multi-level variables (these two types of variables are described below);

(6) The file must be ASCII and it must be in a form that can be read using FORTRAN FORMAT statements.

Several keywords for the ONSITE pathway are identical, or nearly so, to those on the SURFACE and UPPERAIR pathways and there are many new keywords. The basic requirements to read the data are described immediately below, and additional keywords that are important, but not required, to estimate dispersion parameters are described later in this section. The basic keywords are:

DATA -	specifies the input file name of the original data;
XDATES -	specifies the period of time to be retrieved from the original data file;
LOCATION -	specifies the station identifier, latitude and longitude and the factor to convert the time of each data record to local standard time;
QAOUT -	specifies the output file name from the QA process/input file name to Stage 2;
VARS -	defines the order of the variables as they appear in the DATA file; this keyword is repeatable;
FORMAT -	defines the format of the variables as they appear in the DATA file; this keyword is repeatable.

All of these keywords are mandatory. The order of these keywords within the ONSITE pathway is not important, although there are a few optional keywords on this pathway where order is important. Notice, too, that there is no EXTRACT keyword.

```
JOB
  ERRORS    LVTQA.ERR
  REPORT    LVTQA.RPT

ONSITE
  DATA           LVTOSITE.DAT
  XDATES    88/3/1  TO  88/03/10
  LOCATION  LOVETT 74.0W 41.3N  0

  VARS           1  OSDY OSMO OSYR OSHR OSMN
  VARS           2  HT01 SA01 SW01 TT01 WD01 WS01
  VARS           3  HT02 SA02 SW02 TT02 WD02 WS02
  VARS           4  HT03 SA03 SW03 TT03 WD03 WS03

  FORMAT    1  (5(I2,1X))
  FORMAT    2  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  FORMAT    3  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  FORMAT    4  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)

  FREQ_SECT MONTHLY 1
  SECTOR 1  0    360

  CHARS   1   1 0.350  0.800  0.300
  CHARS   2   1 0.350  0.800  0.300
  CHARS   3   1 0.350  0.800  0.300
  CHARS   4   1 0.250  0.400  0.500
  CHARS   5   1 0.250  0.400  0.500
  CHARS   6   1 0.120  0.200  0.700
  CHARS   7   1 0.120  0.200  0.700
  CHARS   8   1 0.120  0.200  0.700
  CHARS   9   1 0.200  0.600  0.500
  CHARS  10   1 0.200  0.600  0.500
  CHARS  11   1 0.200  0.600  0.500
  CHARS  12   1 0.350  0.800  0.300

  QAOUT     LVTOQA.DSK
```

Figure 2.5. Example Runstream to QA On-Site Tower Data.

Figure 2.5 shows a runstream file that processes on-site data stored in a file called ONSITE.DAT. The keywords for the JOB pathway are the same as before. The DATA, XDATES, LOCATION and QAOUT keywords for the ONSITE pathway are nearly identical in content and purpose to the same keywords for the SURFACE and UPPERAIR pathways. The only differences are:

1) a file format is not specified with the DATA keyword;

2) the site identifier for the LOCATION keyword can be any eight character descriptor since there is no extraction process that checks the content of this field.

Refer to the previous subsections for the SURFACE and UPPERAIR pathways for a more detailed discussion of these now-familiar keywords.

There are two types of variables: scalar and multi-level. The scalar variables are single-valued measurements. Examples of scalars are net radiation and sensible heat flux. The multi-level variables can be reported at one or more heights and can come from an instrumented meteorological tower, a remote sensor (e.g., sodar or lidar), or any other meteorological instrumentation that can observe data at several levels in the atmosphere (e.g., tethered balloon). For this tutorial, data are assumed to come from an instrumented tower. Examples of multi-level variables are temperature and wind speed. Each variable is identified by a 4-character name; the allowable names are listed in Appendix C. The complete name of multi-level variables depends on the level at which they are observed. The naming convention for multi-level variable is described below and in Section 3.

The VARS and FORMAT keywords are the keys to reading the on-site data. For every VARS keyword statement there must be a corresponding FORMAT keyword statement in the runstream file. The two keywords are linked through an index that identifies which data record in the observation period is being referenced. Figure 2.6 shows four observations from ONSITE.DAT to illustrate the use of these two keywords. Note that each observation consists of a group of four records, with the date and time in the first record, followed by three levels of tower data.

The VARS keyword defines the variables present on each data record in the order they appear in the input file. The first field after the VARS keyword contains an index indicating the data record in the observation group the keyword statement references. The format of the variables on each data record is specified on a corresponding FORMAT keyword statement. This keyword contains the index indicating which record in the observation group the keyword references followed by the Fortran format string, enclosed in parentheses, that is used to read the data. The format must comply with all the rules of syntax for constructing a FORMAT statement. Refer to any introductory text on Fortran programming or compiler manual for these rules. There can be a maximum 20 data records per observation period and 20 variables on any one data record. Remember that the maximum length of a keyword statement is 80 characters.

Blanks in the format specification must be avoided because AERMET recognizes both blanks and commas as field delimiters on keyword statements. With the presence of the commas in the format, blanks in the format specification (that a user might use to improve readability of the format) will cause an error in processing the keyword statement. The list-directed format specifier (an asterisk, *) cannot be used because the string "(*)" is not recognized by the compilers (the parentheses are required).

Not all of the variables present in the on-site data file need to be read. Any superfluous data can easily be skipped over using the X, T and / edit descriptors. However, *the same format used to read the original on-site data file is also used to write the QA file*. If some variables or entire lines of data are skipped, then the QA output file will contain corresponding blank fields and/or blank lines.

1	3	88	1	0						
1	3	88	1	0	10.0	48.7	0.110	0.64	317.50	0.80
1	3	88	1	0	50.0	14.7	99.000	1.84	323.30	2.00
1	3	88	1	0	100.0	9.1	0.410	1.64	320.50	3.70
1	3	88	2	0						
1	3	88	2	0	10.0	22.5	0.080	0.34	273.10	0.90
1	3	88	2	0	50.0	15.6	99.000	1.04	304.00	1.50
1	3	88	2	0	100.0	13.4	0.340	0.74	308.50	2.50
1	3	88	3	0						
1	3	88	3	0	10.0	63.3	0.080	-0.76	276.50	0.60
1	3	88	3	0	50.0	32.9	99.000	0.04	331.70	1.30
1	3	88	3	0	100.0	27.0	0.390	-0.16	319.10	2.30

Figure 2.6. Three Observation Periods of On-Site (Tower) Data for March 1, 1988.

In this example, the first data record contains the day, month, year and hour of the observation as defined by OSDY, OSMO, OSYR and OSHR. The record is read with the format: (4(I2,1X)). The parentheses are required to properly define the format. There are no scalar variables. If there were, they could appear after the date/time group or on one or more records by themselves. The second through fourth records contain data measured on the tower and are read with the format: (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2). Notice that the day, month, year and hour are repeated on each record, but they are skipped on records 2 - 4 by virtue of the '16X' at the beginning of the format. The variable names for multi-level data consist of a 2-letter prefix and a 2-digit suffix. The prefix identifies the variable and the suffix is the index of the measurement level. Each record contains temperature (TTnn), wind speed (WSnn), wind direction (WDnn), and two components of turbulent wind fluctuations (SEnn and SAnn), where the 'nn' refers to the level on the tower. For example, HT01 is the height on the tower at level 01, while WS03 is the wind speed at the third level. Even though the second through fourth records are all read with the same format, the format for each record is specified separately on a FORMAT keyword statement.

With these few keyword statements, AERMET will read on-site data, provided the format is specified correctly. There are three very important keywords that are optional but are highly recommended. These keywords define the surface characteristics at the site where the data are applied. There is no other method to specify this information for AERMET (e.g., through the input data file). These keywords, which are used in Figure 2.5, are:

FREQ_SECT -	specifies the frequency and number of wind direction sectors for defining the site-specific characteristics of surface roughness length, albedo and midday Bowen ratio; this keyword must appear before the next two keywords;
SECTOR -	specifies the lower and upper bounds of individual wind direction sectors; up to 12 sectors can be defined and the directions so specified must account for all directions;
CHARS -	defines the albedo, midday Bowen ratio and surface roughness length by frequency and sector;

The FREQ_SECT statement defines the frequency with which the site characteristics vary and the number of contiguous, nonoverlapping wind direction sectors that define unique upwind surface characteristics. **This statement must precede the SECTOR and CHARS keyword statements**. Time periods can be either ANNUAL, SEASONAL, or MONTHLY. For program operation, the definition of SEASONAL in AERMET follows the calendar rather than any vegetation cycles. Winter corresponds to December, January and February; spring corresponds to March, April and May; summer corresponds to June, July and August; and autumn corresponds to September, October and November. The user will have to determine how the definitions of the seasons in the tables and in the program apply to each other for a particular application.

SECTOR keyword statements define the beginning and ending directions of each sector, with one sector defined on each sector keyword statement. The sectors are defined clockwise as the direction from which the wind is blowing, with north corresponding to 360°. The sectors must cover the full circle, and these must be defined so that the end of one sector is the beginning of another, i.e., for multiple sector definitions, the beginning value for one sector must match the end value of the previous sector. The beginning direction is considered part of the sector, while the ending direction is excluded from the sector. See Section 5 for a detailed discussion on defining the wind direction sectors and associated surface characteristics.

The parameters on the CHARS keyword are used in the computation of the fluxes and stability of the atmosphere. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for thick deciduous forests to 0.90 for fresh snow. The Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux. Although the Bowen ratio can have significant diurnal variation, it is used to determine the planetary boundary layer parameters for convective conditions. During the daytime, the Bowen ratio usually attains a fairly constant positive value, which range from about 0.1 over water to 10.0 over desert at midday. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from less than 0.001 m over a calm water surface to 1 m or more over a forest or urban area.

Default values for the surface characteristics exist in AERMET, but are not recommended because they are very general and not likely to apply to the on-site location where the measurements are taken. These defaults are:

Frequency:	annual
Number of sectors:	1
Sector definition:	0-360
Albedo, bowen ratio, roughness length:	0.25, 0.75, 0.15 (meters)

These values are typical of a mixture of grassland and occasional forest and average moisture conditions.

Tables 3.1 - 3.3 (from Paine, 1987) show typical values of the albedo, Bowen ratio and surface roughness length as a function of season and land use type. The season in these tables are based on the emergence and growth of vegetation. For example, March in one part of the country may represent spring whereas in another part of the country it may well be winter.

The surface characteristics for each time period and wind sector are specified on CHARS statements, one for each combination of frequency and direction sector. This statement includes the frequency and wind sector indices, the albedo, Bowen ratio and roughness length, in that order. In the example in Figure 2.5, the surface characteristics vary by calendar month (MONTHLY) and are the same for all wind directions (the "1" after MONTHLY on the FREQ_SECT keyword statement). Therefore, there are 12 CHARS keyword statements.

As a further example of the use of these keywords, consider the following example.

```
FREQ_SECT  SEASONAL  2
SECTOR     1     45     270
SECTOR     2     270    45
CHARS      1     1      0.15   2.00   0.12
CHARS      1     2      0.23   0.75   0.05
CHARS      2     1      0.15   2.00   0.12
CHARS      2     2      0.23   0.75   0.05
CHARS      3     1      0.15   2.00   0.12
CHARS      3     2      0.23   0.75   0.05
CHARS      4     1      0.15   2.00   0.12
CHARS      4     2      0.23   0.75   0.05
```

The characteristics vary by both time (SEASONAL) and wind direction (the "2" following SEASONAL). The first integer after the CHARS keyword indicates the season for which the surface characteristics apply, where 1 corresponds to spring (calendar months March, April and May), 2 to summer (June, July and August), 3 to autumn (September, October, and November) and 4 to winter (December, January, February). The second integer after the CHARS keyword indicates the wind direction sector, alternating between 1 and 2, and corresponds to the indices and sectors defined on the SECTOR keyword statement.

If the maximum frequency and sectors were defined, then it would require 144 (12 frequencies and 12 sectors) CHARS statements to completely define the surface characteristics.

If there is no file of on-site data, these keyword statements still should be included to reflect conditions where the National Weather Service data are collected. For this situation, these characteristics can be specified at the time of Stage 2 processing (merging data) or Stage 3 (estimating the dispersion parameters).

There are several optional keywords available for the ONSITE pathway and perform the same function as on the SURFACE and UPPERAIR pathways. These are:

AUDIT - adds variables to the list of variables to be tracked during QA;

RANGE - modifies the default QA bounds, missing value indicator for the variable specified;

NO_MISSING - specifies those variables being tracked (audited) for the QA to not report occurrences of missing values; this keyword is useful if an audited variable is missing most of the time, thus reducing the size of the error/message file;

There are several new, optional keywords for the ONSITE pathway:

DELTA_TEMP - defines the height(s), in meters, for temperature difference data;

HEIGHT - defines the heights of the on-site measurements; this keyword is used if the heights are not included on the VARS keyword statements;

MIN_WIND - sets the minimum detectable wind speed (meters/second); default value is 1.0 m/s;

OBS/HOUR - number of observation periods per hour; required only if the number of periods exceeds 1/hour;

All the keywords are discussed in detail in Section 3, and a synopsis of each is provided in the appendices.

2.2.2 Stage 2 - MERGE Pathway

Stage 2 is the merge processing, which simply combines the available data into a single, formatted ASCII file time with the data grouped in 24-hour periods in local standard time. It is written as an ASCII file so that it may be transported and processed on other computers or with versions of AERMET compiled with other software packages (e.g., both Lahey- and Microsoft-compiled versions of AERMET can read the file). The merge must be executed as a stand-alone run. Neither Stage 1 nor Stage 3 data processing can be performed with the merge. If the user attempts such a process, AERMET issues an error message and will not perform the merge. The basic, and only, keywords for the MERGE pathway beyond the pathway identifier are:

OUTPUT - specifies the output file name of merged data/input file name for Stage 3;

XDATES - specifies the period of time to be retrieved from the input files and merged together.

The input files to the merge are specified on the QAOUT keyword statements for the SURFACE, UPPERAIR and ONSITE pathways. Any combination of files can be merged, but a merge cannot be performed with NWS upper air data alone. AERMET interprets this situation as an error and stops processing. Since the merge is the only processing allowed, the QAOUT keyword statements are the only statements present for the SURFACE and UPPERAIR pathways. If on-site data are to be merged, the ONSITE pathway contains the QAOUT keyword. The example in Figure 2.7 uses the three files that were created from the QA process the SURFACE, UPPERAIR and ONSITE pathways described in Sections 2.2.1.2 - 2.2.1.4. The output from the merge process is MERGE.DSK, as defined by the OUTPUT keyword.

```
JOB
  REPORT    MERGE.RPT
  ERRORS    MERGE.ERR

SURFACE
  QAOUT     SFCQA.DSK

UPPERAIR
  QAOUT     UPAIRQA.DSK

ONSITE
  QAOUT     LVTOQA.MET

MERGE
  OUTPUT    MERGE.DSK
  XDATES    88/3/1  88/3/4
```

Figure 2.7. Example Runstream to Merge QA Data Files with NWS and On-Site Data.

The range of dates for the merged output file can be specified using an XDATES statement. The syntax is identical to its usage earlier; notice in this example the "TO" has been omitted. If the XDATES statement is omitted, then AERMET merges data starting with the earliest date found in the input data files, and ending 367 days later, even if all data in the input files are exhausted. By using the XDATES keyword, a subset of the data can be merged and processed. This is useful if the user had processed one year of NWS and on-site data, but is interested in a shorter time period for dispersion modeling. In the example, data between March 1, 1988 and March 4, 1988, inclusive, are merged.

The algorithms in Stage 3 for AERMOD require at a minimum NWS upper air and surface data Thus, it is possible that a merged file may not contain any on-site data. However, without on-site data, the site-specific surface characteristics have yet to be specified. Stage 3 processing requires such input, and the default values for these parameters are not recommended. In this case, one would include an ONSITE block without a QAOUT keyword statement (i.e., no data to merge), but with FREQ_SECT, SECTOR and CHARS statements. An example supplying the surface characteristics at the time of merging data is shown in Figure 2.8. This method places these statements in the header of the merged file where they will be carried over into Stage 3 and processed by AERMET when the runstream for Stage 3 is processed.

```
JOB
  REPORT     MERGE.RPT
  ERRORS     MERGE.ERR

SURFACE
  QAOUT      SFCQA.DSK

UPPERAIR
  QAOUT      UPAIRQA.DSK

ONSITE
  FREQ_SECT ANNUAL      2
  SECTOR     1     45   270
  SECTOR     2     270  45
  CHARS      1     1    0.15  2.00  0.12
  CHARS      1     2    0.23  0.75  0.05

MERGE
  OUTPUT     MERGE.DSK
  XDATES     88/3/1  88/3/4
```

Figure 2.8. Example Runstream to Merge QA Data Files with NWS Data and Site Characteristics.

2.2.3 Stage 3 - METPREP Pathway

The meteorological data is prepared for the dispersion model in Stage 3. Currently, AERMET only prepares meteorological data for AERMOD. Stage 3 processing is executed using a different executable program (STAGE3.EXE) and the input runstream file can only include statements for the JOB and METPREP pathways. It is the statements in the METPREP block that control the Stage 3 processing. An example runstream is shown in Figure 2.9. The minimum mandatory keywords used in Stage 3 are:

DATA - specifies the input filename of the merged data;

OUTPUT - specifies the output file of fluxes, scaling parameters, mixing height, near-surface winds and temperature;

PROFILE - specifies the output file of the multi-level observations of temperature, winds and fluctuating components of the wind;

LOCATION - specifies a site identifier, latitude and longitude and the factor to convert the time of each record to GMT;

NWS_HGT - specifies the instrument height for the variable indicated.

One additional keyword that is recommended is:

METHOD - forces a specific processing methodology for the variable specified.

```
JOB
  REPORT    AERMET.RPT
  ERRORS    AERMET.ERR

METPREP
  DATA            MERGE.DSK
  OUTPUT    AERMET.SFC
  PROFILE   AERMET.PFL
  LOCATION  LOVETT   74.00W  41.3N  5
  METHOD    WIND_DIR RANDOM
  NWS_HGT   WIND     6.1
```

Figure 2.9. Example Runstream to Create the Output Files for the Dispersion Model.

The input data file, created by the Stage 2 merge, is identified on the DATA statement. The output files that will be input to the AERMOD dispersion model are identified on the OUTPUT and PROFILE statements. The format of these files is given in Appendix D. Each record of the OUTPUT file contains the surface fluxes of heat and momentum, scaling and stability parameters, boundary layer height, and the site characteristics, winds and temperature that were used to compute these values. The PROFILE file consists of winds, temperature and standard deviations of the wind at each level of the on-site data for each hour of the processed data. An exception to this structure is when there are no on-site data for an individual hour. In this case, a one-level profile is constructed using the NWS winds and temperature. The standard deviations of the wind are set to missing when the NWS data are used for this purpose.

The processing carried out in Stage 3 is location-dependent since the latitude and longitude entered here are used to calculate the position of the sun and the times of sunrise and sunset. It is very important to specify these values for the application site, i.e., the source location. The source location may be different from any of those specified for the surface, upper air and on-site data, although it is likely to be the same, or nearly so, as the on-site location (if on-site data were collected). The LOCATION keyword statement is used for this purpose. The site identifier, "LOVETT" in this case, simply identifies the site where the data are applied and is not used for any other purpose. As in previous usage, the latitude and longitude can be specified in either order and must use the N, S, E, W suffixes to place the location relative to the equator and Greenwich. The last item on this statement is used to convert time from LST to GMT, but this parameter is currently not used in any of the calculations.

The only other required keyword statement is NWS_HGT. This keyword has two parameters - one to identify which instrument is being referenced and the second to define the height of the NWS instrumentation in the appropriate units. When on-site data are present, the heights of the measurements are specified with the data. However, when NWS data are used in the computations, there is no instrument height in the data. This keyword is used to define the height. Currently, there is only one weather variable that uses this keyword: WIND, which is measured with an anemometer. Anemometer height can range anywhere from about 20 feet (6.1 meters), which has been the standard height at NWS sites, to 30 feet (9.1 meters) for more recent measurements at some NWS sites. The *Local Climatological Data Annual Summaries* available from NCDC contain a historical record of instrumentation sites and measurement heights for the stations included in the five volume set. In this example, the height of the anemometer that measures the wind is at 7.0 meters.

The METHOD keyword statement is not required but is discussed here because the one option available through this keyword allows AERMET to process NWS wind directions in a manner identical to RAMMET, the meteorological preprocessor for regulatory models such as ISCST2. The only secondary keyword available in AERMET at this time is WIND_DIR. It requires a parameter that identifies whether to randomize NWS wind directions or not. The wind direction recorded by the NWS is to the nearest 10°. The RANDOM parameter directs AERMET to randomize these directions by up to ±5°. The actual process is described in Section 3. The default method is to leave the wind directions as extracted from the archive file (and multiplied by 10). If the default method is preferred, then either the METHOD keyword statement should be omitted or the parameter NWS_10 can be substituted for RANDOM (as a reminder of what option is in force).

Optional keywords that are available for Stage 3 processing are:

XDATES - restricts the processing to a subset of the input data;

MODEL - specifies the dispersion model the estimates are made for; currently AERMET only generates the meteorological data for AERMOD, so this keyword is optional;

TRACE - provides additional information regarding the calculations in the event problems are encountered;

LIST - directs the preprocessor to write the output to the summary file identified on the REPORT keyword on the JOB pathway; useful only if and when AERMET generates binary output files.

A detailed discussion of each of the keywords on the METPREP pathway is provide in Section 3, with a synopsis of each in the appendices.

2.3 RUNNING AERMET

The previous discussion describes the statements used to control AERMET. Once the input runstream file is created, the next step is to run the appropriate program for the stage of processing desired. Running AERMET on a personal computer is described below.

To extract data from an archive file, QA data, or merge data into one file, the executable STAGE1N2.EXE is used. The information in the runstream must be supplied to this program, and is accomplished as follows:

```
STAGE1N2 < STAGE1.INP
```

where STAGE1.INP is a generic runstream filename. Note that it is not necessary to include the .EXE extension to invoke the executable program. The "<" is a redirection symbol and informs the program that input that is to come from the standard input device (the keyboard) will come from the file STAGE1.INP.

If there is a REPORT keyword statement on the JOB pathway, then the summary information will be written to that file. If there is no REPORT keyword, then the summary information will be written to the standard output device, which is the video screen on a PC. More than one screen of summary information is provided, so the information scrolls off the top once the screen is filled. The user has two options: edit the runstream and add a REPORT keyword statement, or redirect the output to a file as follows:

```
STAGE1N2 < STAGE1.INP > STAGE1.LOG
```

The ">" is the redirection symbol that informs the program to send output that would be written to the standard output device (the screen) to the file STAGE1.LOG.

To run the Stage 3 processing to create the meteorological files for the dispersion model, the following command line is used:

```
STAGE3 < STAGE3.INP
```

where STAGE3.INP is a generic runstream filename. The discussion regarding redirection for STAGE1N2 applies to STAGE3, also.

For the entire process from extracting archived data to generating the meteorological input files for a dispersion model, the AERMET system creates many output files. Most of these files are discussed in Section 4. However, a short discussion of the message and summary files from Stage 3 is included here.

For AERMET to process one year of data through Stage 3 (using NWS and on-site data) requires about 45 seconds on a 90 MHz Pentium with 24 Mb of RAM. On a 33 MHz 486 PC with 4 Mb of RAM, nearly 2.5 minutes is required to perform the same calculations. The amount of space required by the data files varies according to the type of data. File sizes range from 0.5 Mb (for one year of upper air soundings) to 6 Mb for a merged data file with all data types (UPPERAIR, SURFACE and ONSITE). Output file sizes for the individual files are given in Section 3.

2.4 MESSAGE AND SUMMARY FILES

The message file contains all the error, warning and informational messages issued by AERMET. An example is shown in Figure 2.10. The interpretation of the numbers in the first field depends on the current processing. If the input runstream file is being processed, the value represents the record number in runstream file (as in the first record in Figure 2.10). If data are being processed, the value represents the Julian day for which the message originated (the remaining records in Figure 2.10). This code is followed by the pathway that is being processed. The pathway is followed by three columns that represent a code used by AERMET to produce a summary table of messages in the summary file. The 'I' indicates an informational message, 'W' is for warning. If an 'E' appears, then a fatal error was encountered; a 'Q' refers to a message from the QA process in Stage 1. The two-digit number indicates a type of error within a specific pathway. Appendix E contains a list of all these codes. The error code is followed by the name of the subroutine from which the message originated. This name is followed by a message that provides some information on the nature of the message. For example, dissecting the second record in Fig 2.10 shows:

1) For either record 61 of the runstream file or Julian day 61 in the data processing, a message is issued. Since there aren't 61 records in the runstream file, then it must be Julian day 61 (the subroutine name also provides a hint, if you know what subroutines are in AERMET).

2) The METPREP pathway is being processed.

3) It is only a warning, with code 78, indicating that a necessary piece of data is missing from an input file;

4) Subroutine SUBST issued the message.

5) The missing piece of data is the on-site temperature, and the NWS temperature is being substituted, and the substitution occurred on Julian day 61 in 1988 at hour 11.

```
13 METPREP    I19 MPSTUP: FOUND "END OF FILE" ON DEVICE DEVIN  5
61 METPREP    W81  SUBST: NO SITE TEMP,SUB NWS: (HHJJJYY) 11 6188
61 METPREP    W81  SUBST: NO SITE WIND,SUB NWS: (HHJJJYY) 11 6188
64 METPREP    I79  FETCH: EOF FOUND ON MERGED INPUT DATA FILE
```

Figure 2.10. Example Message File from Stage 3 Processing.

The summary file, shown in Figure 2.11, is much longer (in this example and for most runs) than the message file. Rather than explain each line of the summary, some of the important sections are identified:

1) The name of the preprocessor and version appear at the top of each page (Fortran carriage control characters are used to create page breaks for printing purposes);

2) The date and time the data were processed - the system clock is interrogated for these values;

3) AERMET terminated normally - an error would have indicated abnormal termination;

4) The input data files that were opened;

5) The dispersion model the meteorological data are for;

6) Special processing instructions;

7) The location for which the data are being processed;

8) The primary meteorological output filename;

9) A table summarizing the messages issued by AERMET;

10) All warning and error messages are repeated at the end of this report.

```
1       AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                   TODAY'S DATE AND TIME: 16-JUL-95 AT 14:50:28

                     PROCESSING OF MERGED METEOROLOGICAL DATA


                      ATTEMPT PROCESSING OF METEOROLOGICAL
                       DATA FOR USE BY A DISPERSION MODEL.

                        ********************************
                        *** JOB TERMINATED NORMALLY  ***
                        ********************************


     1. INPUT/OUTPUT FILENAMES AS DETERMINED
        DURING SETUP PROCESSING.

        AERMET.RPT                                        OPENED   SUCCESSFULLY
        AERMET.ERR                                        OPENED   SUCCESSFULLY
        MERGE.DSK                                         OPENED   SUCCESSFULLY
        AERMET.SFC                                        OPENED   SUCCESSFULLY


     2.  DISPERSION MODEL DEFINED DURING SETUP

         ****************************************
         *                  AERMOD              *
         ****************************************

     3. PROCESSING DEFINITIONS AS DETERMINED
        DURING SETUP PROCESSING.

        PROCESS        SCHEME

        WIND DIRECTION   RANDOM  RANDOMIZE NWS WIND DIRECTION TO BE +/- 5 DEGS

     4. LOCATIONS OF METEOROLOGICAL DATA DETERMINED
        DURING SETUP PROCESSING.

    DATA            SITE      LONGITUDE   LATITUDE
   PATHWAY           ID       (DEGREES)   (DEGREES)

    UPPERAIR    00014735       73.80W       42.75N
    SURFACE        14735       73.80W       42.75N
    ONSITE        LOVETT        74.0W        41.3N

        *****************************************
        * LONGITUDE AND LATITUDE FOR PROCESSING *
        *          74.00        41.30           *
        *****************************************


     5. FILENAMES OF OUTPUT DISK FILES.

        THE LISTING OF WARNINGS AND ERROR MESSAGES
        GENERATED BY THIS RUN IS STORED IN FILE:
          AERMET.ERR

        THE METEOROLOGY GENERATED FOR THE DISPERSION
```

Figure 2.11a. Example Summary Report from Stage 3 Processing.

```
1       AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                      TODAY'S DATE AND TIME: 16-JUL-95 AT 14:50:28
                        PROCESSING OF MERGED METEOROLOGICAL DATA

                 ********************************************************
                 ***                JOB TERMINATED NORMALLY           ***
                 ********************************************************

                         **** AERMET MESSAGE SUMMARY TABLE ****

            0- 9    10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
          ----------------------------------------------------------------------

      METPREP
         E   0       0       0       0       0       0       0       0       0
         W   0       0       0       0       0       0       0       2       2
         I   0       1       0       0       0       0       0       1       2
         T   0       0       0       0       0       0       0       0       0
          ----------------------------------------------------------------------
             0       1       0       0       0       0       0       3       4

        ****    WARNING MESSAGES ****
        61 METPREP    W81  SUBST: NO SITE TEMP,SUB NWS: (HHJJJYY) 11 6188
        61 METPREP    W81  SUBST: NO SITE WIND,SUB NWS: (HHJJJYY) 11 6188

        ****     ERROR MESSAGES  ****

               ---  NONE  ---
```

Figure 2.11b. Continuation of the Example Summary Report from Stage 3 Processing.

2.5. COMBINING PROCESSING STEPS

The tutorial above requires several separate runs to generate the dispersion parameters. Several steps in Stage 1 can be combined to reduce the number of times the programs must be run. However, AERMET requires a minimum of three separate steps to process the data - one step for each stage of processing.

One example of combining steps was used throughout the tutorial - the extract and QA of data was performed in one run. Another way to combine steps is to extract and QA all available data types - hourly surface observations, upper air data, and on-site data - in one run. The runstream file to do this is shown in Fig 2.12. It is really a concatenation of several of the runstream files above, but with one JOB pathway rather than three. The advantage to this procedure is in minimizing the number of input runstream files and the time spent in running Stage 1. The disadvantage is that an error may stop all processing and the warning, informational and QA messages are all in one (possibly very large) file, which could make it difficult to sort through the messages to be sure that all the data types were processed correctly.

It is up to the user to determine how best to process the data. An initial approach may be to perform the extract and QA process separately and for each data type separately. When the user gains some familiarity with the programs, the input runstream files and the output, then the steps can be combined to speed up the process.

```
JOB
  REPORT    EXQA3.RPT
  ERRORS    EXQA3.ERR

SURFACE
  DATA      S1473588.144 CD144FB 1
  EXTRACT   SFCEXT.DSK
  QAOUT     SFCQA.DSK
  LOCATION  14735  73.80W  42.75N  0
  XDATES    88/3/1  TO  88/3/10

UPPERAIR
  DATA      14735-88.UA 6201FB 1
  EXTRACT   UPAIREXT..DSK
  XDATES    88/3/1 TO 88/3/10
  LOCATION  00014735  73.80W  42.75N  5
  QAOUT     UPAIRQA.DSK
  AUDIT     UATT  UATD  UALR

ONSITE
  DATA      LVTOSITE.MET
  XDATES    88/3/1 TO 88/3/10
  LOCATION  LOVETT 74.0W 41.3N  0
  QAOUT     LVTOQA.MET

  FREQ_SECT MONTHLY 1
  SECTOR 1  0    360

  CHARS   1   1 0.350  0.800  0.300
  CHARS   2   1 0.350  0.800  0.300
  CHARS   3   1 0.350  0.800  0.300
  CHARS   4   1 0.250  0.400  0.500
  CHARS   5   1 0.250  0.400  0.500
  CHARS   6   1 0.120  0.200  0.700
  CHARS   7   1 0.120  0.200  0.700
  CHARS   8   1 0.120  0.200  0.700
  CHARS   9   1 0.200  0.600  0.500
  CHARS  10   1 0.200  0.600  0.500
  CHARS  11   1 0.200  0.600  0.500
  CHARS  12   1 0.350  0.800  0.300

  VARS 1 OSDY OSMO OSYR OSHR OSMN
  VARS 2 HT01 SA01 SW01 TT01 WD01 WS01
  VARS 3 HT02 SA02 SW02 TT02 WD02 WS02
  VARS 4 HT03 SA03 SW03 TT03 WD03 WS03

  FORMAT 1 (5(I2,1X))
  FORMAT 2 (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1x,F7.2)
  FORMAT 3 (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1x,F7.2)
  FORMAT 4 (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1x,F7.2)
```

Figure 2.12. Example Runstream to Extract and QA All Data Types in One Run.

SECTION 3

DETAILED KEYWORD REFERENCE

This section provides a detailed reference for all the keywords available in AERMET, expanding the discussion of the keywords presented in Section 2 and fully explaining those keywords that were presented but not discussed. The discussion in this section assumes that the reader has a basic understanding of the pathway, keyword and parameter approach. Novice users should review the contents of Section 2 to obtain a working knowledge of the approach.

The information in this section is organized by pathway, with the more commonly used keywords for that pathway discussed first. The syntax for each keyword is provided with dummy parameter names rather than specific usage as presented in Section 2. The keyword type - mandatory or optional, repeatable or nonrepeatable, reprocessed - are specified. The definition of these terms is discussed below. Additionally, any special requirements, such as the order within the pathway, are specified.

3.1 DEFINITIONS AND RUNSTREAM FILE PROCESSING

The terms "mandatory" and "optional" indicate whether the keyword for a particular pathway is required to run AERMET (mandatory) or if it enhances the processing (optional). Several keywords may be mandatory or optional depending on the usage, the data, or the point they are first introduced in the processing. For example, QAOUT serves two purposes: to define the output file for Stage 1 QA and to define the input file for Stage 2 merge. While data QA is optional, the keyword is mandatory if the data for the pathway are to be merged. Additional explanation will be provided when the keyword type may be ambiguous. For the discussions in Sections 3.2 - 3.5, the stages to which the keyword refers will be in parentheses following the terms "mandatory" and "optional". If 'All' is specified, then the keyword applies to all stages of processing.

The terms "repeatable" and "nonrepeatable" refer to whether or not the keyword can appear only once (nonrepeatable) or more than once (repeatable) for the same pathway in a runstream file. For example, the ERRORS keyword can appear only once on the JOB pathway, thus it is nonrepeatable. However, the RANGE keyword for assessing the validity of the data can appear multiple times on a pathway, thus it is repeatable. A nonrepeatable keyword may appear multiple times in a runstream file, but only once per pathway. For example, the QAOUT keyword defines the input file for each pathway for Stage 2 (merging data). It can appear only once for each pathway, but it will appear two or three times in the runstream file because there is more than one type of data to merge.

When AERMET processes meteorological data, the runstream file used to control the preprocessor's actions is written at the top of the output file. These records are referred to as header records. Special symbols are added at the beginning of each of these records to control processing in subsequent runs that use the output data. One of the actions is to reprocess the header record, i.e., the headers are read and processed as if they had been included as a part of the current runstream file. If a keyword can be reprocessed, then the term "Reprocessed" is indicated in the keyword type field. By allowing AERMET to reprocess a header record, the user may not have to specify certain keywords for subsequent runs. The best example of this is for the ONSITE pathway on which the user must specify the variables and Fortran format of the data records. Specify them once and AERMET will use the information to read the data in subsequent runs. However, keywords that appear in a runstream are processed last, overriding any actions specified in the header records. Header records are cumulative, i.e., the header records plus runstream file are written to the new output file. For example, if a data file is repeatedly QA'd, then all the old header records plus the records in the runstream file are written at the beginning of the output file.

There are no special requirements for the order of the keywords within each pathway, but it is recommended that a logical order be maintained to be able to understand the processing defined by each runstream file.

The syntax descriptions in the following sections use certain conventions. The keywords are all uppercase and the parameters are all lower case. Square brackets around a parameter indicate that the parameter is optional and a default value will be used if it is omitted.

A word of caution deserves repeating. For any AERMET run, all output files are opened with STATUS = 'UNKNOWN'. With this specifier, if the file already exists, it will be opened without any opportunity to save it. With the first write action to the file, the contents of an existing file are erased. Before running AERMET, the user should be certain that any output filename specified in a runstream file either does not exist or can be overwritten.

3.2 JOB PATHWAY

The JOB pathway appears in all AERMET runstream files. The primary purpose of the JOB pathway is for specifying the filenames for reporting all the preprocessor actions that are to be performed for the particular run. The beginning of this pathway is identified by the JOB keyword statement, which has the syntax and type as follows:

Syntax:	JOB
Type:	Mandatory (All), Nonrepeatable

The keyword JOB appears on a line by itself and is followed by the one or more keywords for the pathway. However, if the JOB pathway appears first in the runstream file, the line with JOB on it can be omitted, i.e., only the JOB pathway keyword statements need to be specified. We do not recommend this approach, and suggest always including the JOB keyword.

3.2.1 Messages From AERMET - ERRORS

All error, warning and informational messages, including information from the QA and any data tracing options, issued by AERMET are written to the filename specified on the ERRORS keyword statement. The contents of this file are discussed in Section 4. This keyword is mandatory because the program later interrogates this file to summarize the processing. The syntax and type are:

Syntax:	ERRORS *message_filename*
Type:	Mandatory (All), Nonrepeatable

The *message_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

3.2.2 Run Summary - REPORT

At the conclusion of a run, AERMET interrogates the message_file, tabulates the different types of messages (errors, warnings, etc...), and summarizes all the actions for that particular run in a file specified on the REPORT keyword statement. The contents of a run summary are discussed in Section 4. The syntax and type for this keyword are:

Syntax:	REPORT *summary_filename*
Type:	Optional (All), Nonrepeatable

The *summary_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

This keyword is optional. If it is omitted, then the summary is written to the output control device connected to logical unit 6. On a personal computer, this unit is the video monitor. This information can be captured using redirection (as discussed in Section 6).

3.2.3 Checking the Runstream File for Errors - SYNTAX

AERMET processes all the statements in a runstream file prior to processing any data. Incomplete information on a keyword statement or the omission of a keyword statement will cause AERMET to abort the run and issue error or warning messages. The SYNTAX keyword allows AERMET to process the runstream file and report any problems without performing any data processing. The user can review the summary and message files and correct any errors or make any changes to the runstream file prior to actually processing data. WARNING: AERMET opens all output files and writs the header records to those files, overwriting any data in the file if the file existed. The syntax and type of the SYNTAX keyword are:

Syntax:	SYNTAX
Type:	Optional (All), Nonrepeatable

There are no parameters that accompany this keyword. It appears on a line by itself.

The user gets a full report of the processing of the runstream file, i.e., the ERRORS file and REPORT file are generated and can be reviewed. In the REPORT file, the following appears near the top of each page in the file:

```
*******************************************************
***   THIS RUN IS ONLY A CHECK OF THE INPUT IMAGES   ***
*******************************************************
```

3.3 SURFACE PATHWAY

The SURFACE pathway defines all the necessary information for processing National Weather Service hourly surface weather observations. These data provide information on temperature, winds, and cloud cover (particularly important) that can be used in estimating dispersion parameters. The data generally come from first order observation stations (observations 24 hours per day) located at or near airports. The beginning of this pathway is identified by the SURFACE keyword statement, which has the syntax and type as follows:

Syntax:	SURFACE
Type:	Mandatory (Stages 1 and 2), Nonrepeatable

AERMET can read and process a variety of formats, each discussed below with the DATA keyword statement.

3.3.1 Retrieving Archived Data - DATA

NWS surface observations data are stored in a variety of formats that are not easily interpreted. Data in one of these formats is referred to as archived data. One of AERMET's functions is to read and interpret the archived data and to write the results in another format for later processing. The DATA keyword statement is used to specify the filename and define the archive file format for AERMET. The syntax and type for the DATA keyword are:

Syntax:	DATA *archive_filename file_format factor* [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

The *archive_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive_filename* is 48 characters.

The *file_format* must be one of the following: CD144FB, SCRAMFB. The prefixes CD144 and SCRAM refer to a particular archive format while the suffix FB indicates that each logical record in the file is fixed-length records, i.e., constant length. The FB is a result of designing AERMET to process data on magnetic tape where the data could be variable-length records. Although the information is not relevant for data on a personal computer, it must still be present for AERMET to process the data, otherwise an error message is issued and no data are processed. For the discussion below, the FB will be dropped.

The CD144 format is an older standard format used by the National Climatic Data Center for archiving surface observations. Alphanumeric characters one to four columns in length are used to represent various weather variables. All the weather variables for one hour are stored on one logical record and the length of each logical record is 79 characters.

When requesting hourly surface data from NCDC, the user must make a specific request for the CD144 format because this standard was replaced in the 1980's by a new standard, the TD-3280 format. This new standard is an element-based format in which all observations for a single weather element (e.g., dry bulb temperature) for an entire day are stored as contiguous data. This format, however, does not lend itself directly to processing on personal computers. A discussion of the TD-3280 format and data processing can be found in Appendix E.

The SCRAM format is derived from the CD144 format. It is available from the EPA's Technology Transfer Network electronic bulletin board under the Support Center for Regulatory Air Models (SCRAM) section. There are fewer weather variables reported - only the necessary variables for processing data for air quality models such as the Industrial Source Complex (ISC2) models. Each logical record is 28 characters and includes data for cloud ceiling height, dry bulb temperature, wind speed and direction, and opaque sky cover. AERMET requires surface station pressure for some of its computations (e.g., density of air). If the SCRAM format is used, then pressure is not available and a sea level pressure in a standard atmosphere (1013.25 millibars) is assumed.

The *factor* defines the number of logical records in one physical record for fixed-length logical records and is intended primarily for use with magnetic tapes. However, AERMET has no *a priori* knowledge of the media the data are on, so this value must be specified for all data, independent of the media. One logical record is composed of data for a single observation period, and one physical record is composed of one or more logical records. For data on a personal computer, this factor is most likely to be one (1). In other words, each logical record is also a physical record. For the SCRAM data and CD144FB format that is obtained from NCDC on PC diskettes, one logical record is one physical record, thus the user must specify "1" for this field. For data on tape, however, the *factor* is usually greater than one (for example, 10 or 100) to save space on the tape. Additional information on the *factor* for magnetic tapes is discussed in Appendix E.

The last field on the DATA record, *type*, indicates whether the data follow the ASCII or EBCDIC collating sequence. The default collating sequence is ASCII. It refers to processing data on magnetic tape, and in particular tapes on an IBM mainframe computer, and is not required for processing data on a personal computer. Unless AERMET is processing data on an IBM mainframe computer, this field can be left blank.

3.3.2 Saving Dearchived Data - EXTRACT

The EXTRACT keyword statement specifies the filename to which the data retrieved from the archive data are written. The syntax and type are:

Syntax:	EXTRACT *extracted data filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *extracted_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

3.3.3 Extracting a Subset of the Data - XDATES

The amount of data extracted from an archive file can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field, and there cannot be any spaces before or after the slash (/). The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword statement is processed.

3.3.4 Identifying the Station - LOCATION

One station and one year of data are generally in a file on a personal computer, whereas multiple stations and multiple years of data may exist on magnetic tape. To allow AERMET to process data on multiple computer platforms, information on which station's data to extract from the archive file is required, even for personal computer-based data. The LOCATION keyword statement performs this function. The parameters on this keyword statement specify the station identifier, latitude and longitude, and a time adjustment factor to correct the data to local standard time. The syntax and type are:

Syntax:	LOCATION *site id NWS lat/long NWS long/lat tadjust*
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an five character alphanumeric specifier that identifies the station for which data are extracted. For the standard formats listed on the DATA keyword statement, these identifiers are five-digit WBAN (Weather Bureau Army Navy) numbers. However, the *site_id* must be specified with leading zeros to fill the entire eight-character field (e.g., 03928 must be entered as 03928). A master list of WBAN numbers for stations throughout the world can be obtained from the NCDC in Asheville, NC.

The NWS station latitude (*lat*) and longitude (*long*) can be entered in either order because the user must include a suffix on each: an N or S with the latitude and W or E with the longitude. AERMET interprets the suffix and retains the information in the appropriate variable name. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N" in AERMET. AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north/south and east/west. The NWS latitude and longitude on the SURFACE pathway are not used for any purpose at this time. They are simply another way to identify the NWS station being processed.

The final parameter for this keyword, *tadjust*, is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The default value for *tadjust* is zero. For NWS the surface data formats processed by AERMET, the reported time is local standard time. Therefore, *tadjust* is zero in most applications, and because zero is the default value, it can be omitted. This parameter is retained in AERMET to provide flexibility in processing other data types should they need the time adjusted and to maintain consistency with the keyword usage on other pathways.

3.3.5 How good are the data? - QAOUT

One of the purposes of AERMET is to assess the quality of the data to insure that high quality data are used in estimating the dispersion parameters. The quality assessment (QA) is performed by including the QAOUT keyword statement in a runstream file. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2) if there are data to merge, Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters. For one year of data, the size of the output file is approximately 1.3 Mb.

As suggested by the type of keyword, quality assessment is an optional process. In other words, the user does not have to perform a quality assessment prior to merging the data. However, we strongly recommend this step to identify possible errors in the data that are used to derive the dispersion parameters.

Presently, AERMET's capabilities in this area are limited to verifying that the values of the weather variables are not outside a range of acceptable values and keeping track of the number of missing values. These checks operate on one observation period at a time, i.e., temporal variations of the data are not checked.

On the SURFACE pathway, when a quality assessment is performed, several of the weather variables are automatically tracked (audited) and included in a summary of the QA process. These variables are: station pressure, total and opaque sky cover, dry bulb temperature, wind speed and wind direction. The hourly value of each variable is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. The number of times the weather variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file defined on the REPORT keyword. Each time a value is missing or violates one of the bounds, a two-line message is written to the message file defined on the ERRORS keyword statement. The message includes the value, the violation, and the data and time of occurrence.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator. These values can be changed by the user through the use of the RANGE keyword, as described below. Also, the user can QA additional weather variables by using the AUDIT keyword.

3.3.6 Adding Weather Variables to the QA - AUDIT

As mentioned in the previous section, there are only five weather variables that are tracked by default during a QA. The user can track additional weather variables for a particular AERMET run by specifying the variable name on an AUDIT keyword statement. The syntax and type for this keyword are:

Syntax:	AUDIT *sfname*1 ... *sfname*n
Type:	Optional (Stage 1), Repeatable

where *sfname*1, ..., *sfname*n are the variable names of the weather variables as defined in Table B.2 of Appendix B. As many variable names can be specified on a single keyword statement that will fit within the 80-character limitation of a keyword statement. Since this keyword is repeatable, more than one AUDIT keyword statement can be used to define all the additional variables to track.

While the AUDIT keyword can add weather variables to the QA, there is no method to remove any of the default weather variables from the QA. They are always reported.

3.3.7 Changing the Default Values for the QA - RANGE

As mentioned in earlier, the user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *sfname lower_bound* <[=] *upper_bound missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *sfname* is the variable name of the weather variable as defined in Table B.2 of Appendix B, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value code. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified on with this keyword even if a parameter is not changing.

Data for the SURFACE pathway are written as integers with some variables having been multiplied by 10 when extracted to retain significant digits. Table C.2 provides information on which variables have been multiplied. The default upper and lower bounds are multiplied also, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword statement. However, no such conversion is necessary for the *missing_indicator*.

Several weather variables have been concatenated to form a single variable in the *extracted_data_file*. These variables are noted in Table C.2 and are related to cloud cover, weather type and height. If the user wants to modify the bounds and the missing value indicator through a RANGE keyword statement, these values must be concatenated, also.

3.3.8 Reducing the Number of QA Messages - NO_MISSING

As mentioned in the discussion for the QA keyword, a two-line message is written to the message file (defined on the ERRORS keyword statement) every time a bound is violated or a value is missing. If one weather variable that is tracked for reporting (either by default or defined on an AUDIT keyword statement) is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message file, the NO_MISSING keyword statement can be included during a QA. The syntax and type are:

Syntax:	NO_MISSING *sfname*1 ... *sfname*n
Type:	Optional (Stage 1), Repeatable

where *sfname*1, ..., *sfname*n are the variable names of the weather variables to omit from the message file. The number of missing values is still tallied and reported in the summary file.

3.4 UPPERAIR PATHWAY

The UPPERAIR pathway defines all the necessary information for processing National Weather Service rawinsonde (sounding) data. These data provide information on the vertical structure of the atmosphere. The height, pressure, dry bulb temperature, relative humidity (which is used to obtain dew point temperature) and winds are reported. The data come from about 50 stations around the United States, and most countries in the world have an upper air observation program. The data are generally collected twice-daily, at 0000 Greenwich Mean Time (GMT) and 1200 GMT (these times are also referred to as 00Z and 12Z, respectively). The beginning of this pathway is identified by the UPPERAIR keyword statement, which has the syntax and type as follows:

Syntax:	UPPERAIR
Type:	Mandatory (Stages 1 and 2), Nonrepeatable

AERMET can read and process one format, as discussed below with the DATA keyword. However, if the user can reformat data that may have been taken during an on-site observation program into the proper format, which is described in Appendix B, then those data could be used in place of NWS data. AERMET has been designed to accept 24 soundings per day. Note though, for AERMET to correctly read the file, a header record of three asterisks (in columns 1-3) must appear on a single record before the data.

3.4.1 Retrieving Archived Data - DATA

NWS rawinsonde data are stored in a variety of formats. However, AERMET is designed to read only one of those formats. As with hourly surface observations, data stored in this format is referred to as archived data. AERMET reads and interpret the sounding data and writes it to a separate file for later processing. The DATA keyword statement is used to specify the filename and define the archive file format for AERMET. The syntax and type for the DATA keyword are:

Syntax:	DATA *archive_filename file_format factor* [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

The archive file must conform to the naming conventions appropriate to the computing platform. The maximum length of the archive file is 48 characters.

When a user orders the TD-6201 upper air on diskette from NCDC, the data are stored as fixed-length records, i.e., the length of each record is the same. The *file_format* must be specified as 6201FB for the TD-6201 data on diskette, except as noted below. The 6201 associates the particular data format that AERMET can process, and the FB indicates fixed-length records. There can be up to 200 levels reported per sounding, spanning three physical records on the diskette. Each record consists of 2876 characters, with the first 32 characters used to identify the sounding and 36 characters per sounding level, with 79 levels reported per record. If there are less than 79 levels, then missing data indicators are used to 'fill out' a record such that the record length is constant for all observation periods. If there are more than 80 - 158 sounding levels, then a second record is present in the data. For more than 158 sounding levels, a third record is present. AERMET only processes the first physical record, skipping any additional records for a single sounding, because the measurements are above 16,000 meters, and more likely above 20,000 meters, at this level. Currently, AERMET does not need information above about 5000 meters. The structure of the upper air sounding data can be found in NCDC's documentation for the TD-6200 series data (NOAA, 1989).

The upper air data can be ordered on magnetic tape for use on other computing platforms. Processing data on magnetic tape is discussed in Appendix E. Generally, data on magnetic tape are requested and delivered as variable-length because this format is most efficient at storing data - only those sounding levels at which data are observed are in the archive file.

The *factor* defines the number of logical records in one physical record and is intended primarily for use with magnetic tapes. However, AERMET has no *a priori* knowledge of the media the data are on, so this value must be specified for all data, independent of the media. One logical record is composed of data for a single observation period (sounding), and one physical record is composed of one or more logical records. For data on a personal computer, this factor is most likely to be one (1). In other words, each logical record is also a physical record. For data on tape, however, the *factor* may be greater than one (for example, 10 or 100). Additional information on the *factor* for magnetic tapes can be found in Appendix E.

The last field on the DATA record, *type*, specifies whether the data follow the ASCII or EBCDIC collating sequence. The default collating sequence is ASCII and can be left blank when processing data on a personal computer. The EBCDIC collating sequence is for processing data on an IBM mainframe computer, but this option is not functional in this version of AERMET.

3.4.2 Saving Dearchived Data - EXTRACT

The EXTRACT keyword statement specifies the filename to which the data retrieved from the archive data file are written. The syntax and type are:

Syntax:	EXTRACT *extracted_data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *extracted_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

3.4.3 Extracting a Subset of the Data - XDATES

The amount of data extracted from an archive data file can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces before or after the slash (/). The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword statement is processed.

3.4.4 Identifying the Station - LOCATION

One station and one year of generally are in a file on a personal computer, whereas multiple stations and multiple years of data may exist on magnetic tape. AERMET requires information on which station's data to extract from the archive file, even for personal computer-based data. The LOCATION keyword statement performs this function. The parameters on this keyword statement specify the station identifier, latitude and longitude, and a time adjustment factor to correct the data to local standard time. The syntax and type are:

Syntax:	LOCATION *site id NWS lat/long NWS long/lat tadjust*
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the station for which data are extracted. For the standard formats listed on the DATA keyword statement, these identifiers are five-digit WBAN numbers. However, the *site_id* must be specified with leading zeros to fill the entire eight-character field (e.g., 14735 must be entered as 00014735).

The NWS station latitude (*lat*) and longitude (*long*) can be entered in either order because the user must include a suffix on each: an N or S with the latitude and W or E with the longitude. AERMET interprets the suffix and retains the information in the appropriate variable name. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N" in AERMET. AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north/south and east/west. The NWS latitude and longitude on the UPPERAIR pathway are not used for any purpose at this time. They are simply another way to identify the station being processed.

The final parameter for this keyword, *tadjust*, is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The default value for *tadjust* is zero. For NWS upper air data processed by AERMET, the reported time is Greenwich Mean Time. This value is subtracted from GMT to obtain local standard time. Therefore, in the United States, which is west of Greenwich, the value 5 is specified to convert GMT to Eastern Standard Time, 6 is specified to convert GMT to Central Standard Time, 7 is specified to convert GMT to Mountain Standard Time, and 8 is specified to convert GMT to Pacific Standard Time.

3.4.5 How good are the data? - QAOUT

One of the purposes of AERMET is to assess the quality of the data to insure that high quality data are used in estimating the dispersion parameters. The quality assessment (QA) is performed by including the QAOUT keyword statement in a runstream file. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2) if there are data to merge, Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters. For one year of TD-6201 data, the size of the output file is approximately 0.5 Mb.

As suggested by the type of keyword, quality assessment is an optional process. In other words, the user does not have to perform a quality assessment prior to merging the data. However, we strongly recommend this step to identify any potential problems in the data that are used to derive the dispersion parameters.

Presently, AERMET's capabilities in this area are limited to verifying the values of the upper air data are not outside a range of acceptable values and keeping track of the number of missing values. These checks operate one sounding at a time, i.e., sounding to sounding variations are not checked.

Unlike the SURFACE pathway, there are no variables that are tracked (audited) automatically on the UPPERAIR pathway. The user must specify through the AUDIT keyword statement those variables to QA, as discussed below. For variables so specified, the value of each variable at each level is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. The number of times the variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file (defined on the REPORT keyword). Each time a value is missing or violates one of the bounds, a two-line message is written to the message file defined on the ERRORS keyword statement, containing the value, the violation, the date and time of occurrence and the sounding level.

The number of levels in a sounding and the heights at which the data are recorded vary from sounding to sounding. It is impractical to report on every level. AERMET divides the atmosphere into 10 regions in which to summarize the QA information for the soundings. These regions are based on the thickness increment defined to be 500 meters (in the variable UAINC in the file MASTER.INC). These regions are: surface (the first level in the sounding), every 500 meters up to 4000 meters and everything above 4000 meters. By changing the value of UAINC (and recompiling the software), these regions can be increased and decreased.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator for each variable. These values can be changed by the user through the use of the RANGE keyword, as described below.

3.4.6 Adding Upper Air Variables to the QA - AUDIT

As mentioned above, there are no upper air variables that are tracked by default during a QA. The user can track some or all variables for a particular AERMET run by specifying the variable names on an AUDIT keyword statement. The syntax and type for this keyword are:

Syntax:	AUDIT *uaname*1 ... *uaname*n
Type:	Optional (Stage 1), Repeatable

where *uaname*1, ..., *uaname*n are the upper air variable names as defined in Table B.1 of Appendix B. As many variable names can be specified on a single keyword statement that will fit within the 80-character limitation of a keyword statement. Since this keyword is repeatable, more than one AUDIT keyword statement can be used to define the variables to track.

3.4.7 Changing the Default Values for the QA - RANGE

The user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *uaname lower_bound* <[=] *upper_bound missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *uaname* is the upper air variable as defined in Table B.1 of Appendix B, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value indicator. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified on with this keyword even if a parameter is not changing.

Data for the UPPERAIR pathway are written as integers to the output file with some variables having been multiplied by 10 to retain significant digits. Table C.1 provides information on which variables have been multiplied. The default upper and lower bounds are multiplied as well, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword statement. However, no such conversion is necessary for the *missing_indicator*.

3.4.8 Reducing the Number of QA Messages - NO_MISSING

As mentioned in the discussion for the QA keyword, a two-line message is written to the message file (defined on the ERRORS keyword statement) every time a bound is violated or a value is missing. If one variable that is tracked for reporting is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message_file, the NO_MISSING keyword statement can be included during a QA. The syntax and type are:

Syntax:	NO_MISSING *uaname*1 ... *uaname*n
Type:	Optional (Stage 1), Repeatable

where *uaname*1, ..., *uaname*n are the variable names of the weather variables to omit from the message file. The number of missing values is still tallied and reported in the summary file.

3.4.9 Limiting the Height of the Extracted Data - CEILING

If all goes well during the launch and tracking of a rawinsonde by the NWS, then data may extend up to 30,000 meters (10 millibars) or higher. The number of levels of data in such a sounding may exceed 60. The maximum number of levels of data that AERMET extracts is 30 (which corresponds to about 7000 meters and 400 millibars or higher) or data up to 5000 meters, whichever is reached first. Currently, processing in Stage 3 rarely needs data above 5000 meters. However, for those occasions when data are required for a higher or lower height, the CEILING keyword statement can be used to extend or limit height. The syntax for this keyword is:

Syntax:	CEILING *max_height*
Type:	Optional (Stage 1), Nonrepeatable, Reprocessed

where max_height is an integer value given in meters.

3.4.10 Adjusting Sounding Data - MODIFY

AERMET was born out of another meteorological preprocessor that extracted data from an earlier format of upper air data that was fraught with errors. That earlier preprocessor attempted to correct some of those errors automatically. However, the quality of the data has improved substantially, and AERMET retains some of that functionality, but it is no longer an automatic process. The MODIFY keyword statement informs AERMET to 'turn on' the process and perform some preliminary quality control as the data are extracted. The syntax and type of the keyword are:

Syntax:	MODIFY
Type:	Optional (Stage 1), Nonrepeatable

This keyword does not have any parameters associated with it. By specifying this keyword the following actions occur:

- Some mandatory levels are deleted from the sounding;
- A nonzero wind direction is set to 0 if the wind speed is 0;
- Missing ambient and dew point temperatures are replaced by interpolated values.

If a mandatory sounding level is within one percent of a significant level (with respect to pressure) then the mandatory level is deleted. This modification is performed to reduce the possibility of reporting large gradients during the quality assessment. There is little loss of information in the sounding. However, a sounding may end up with fewer than the current maximum number of levels because the deletion process takes place after the data are extracted from the archive data file (specified on the DATA keyword statement). AERMET does not attempt to read more levels after deleting a level.

The wind speed and wind direction at each level are checked to insure that there are no levels with a zero wind speed and a non-zero wind direction. If one is found, the wind direction is set to zero to represent calm conditions. At present, the winds from the soundings are not used in any dispersion parameter estimates.

If the dry-bulb or dew-point temperature is missing at some level, then an estimate for the missing temperature is made by linearly interpolating to the level in question. The data from the level immediately below and above the level in question are used. If the data that are required for the interpolation are also missing, then no interpolation is performed.

3.5 ONSITE PATHWAY

The ONSITE pathway provides a means of including data recorded during an observation program such as an atmospheric boundary layer field experiment. Such an experiment may utilize an instrumented tower (with data from several levels), a remote sensing device (such as lidar), and instrumentation at or near ground level (such as measuring surface stress). Much of this type of data can be used in AERMET to provide better estimates of the dispersion parameters than using NWS data alone. The beginning of this pathway is identified by the ONSITE keyword statement, which has the syntax and type as follows:

Syntax:	ONSITE
Type:	Mandatory (Stages 1 and 2), Nonrepeatable

There are several keywords that are nearly identical to those found on the SURFACE and UPPERAIR pathways, and there are several keywords that are unique for this type of data. The presence of so many keywords may make the specification of on-site data seem very complex. However, it can be almost as simple as for NWS files. The only additional statements that must be included for on-site data are those required to describe the structure of the data. All other statements are optional and could be omitted.

3.5.1 Retrieving Archived Data - DATA

The file containing the on-site data is specified on the DATA keyword statement. Unlike the SURFACE and UPPERAIR pathways, there is no standard format or content for on-site data. Thus, only the filename is specified on this keyword. The syntax and type for the DATA keyword are:

Syntax:	DATA *data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

3.5.1.1 Where is the EXTRACT keyword?

Unlike SURFACE and UPPERAIR data, on-site data are not stored (archived) in any particular format. Therefore, the data are not "extracted" from an archived format. There is no need for the EXTRACT keyword, and the processing can begin with the quality assessment. Thus, the input file to the QA is defined on the DATA keyword statement.

3.5.2 Defining the File Structure - VARS and FORMAT

The key to reading on-site meteorological data correctly in AERMET is to define what data are present and the format of the data. This task is accomplished with the VARS keyword, which defines the list and order of variables present on a data record, and the FORMAT keyword, which defines the format of that record. These two statements together are much like reading or writing data in a Fortran program (see, for example, Fig. 2.5). The syntax and type of these two keywords are:

Syntax:	VARS *record_index osname*1 ... *osname*n
Type:	Mandatory (Stage 1), Repeatable, Reprocessed

Syntax:	FORMAT *record_index Fortran_format*
Type:	Mandatory (Stage 1), Repeatable, Reprocessed

Each VARS keyword statement is paired with a corresponding FORMAT keyword through the *record_index* field. This index refers to one record of data for an observation period. The indices are numbered sequentially beginning with 1. There can be up to 40 variables on any one data record and up to 20 records per observation period.

The format of the on-site data is reasonably flexible, but subject to the following restrictions:

(1) The data for one observation period can be spread across several records, but the records for one period must be contiguous;

(2) The same variables must appear for all observation periods;

(3) The date and time information for each observation must be on the first record of the period; these may occur in any order within the first record, and must be integer format;

(4) The variables on the VARS keyword statements must be a subset of those listed in Appendix B, Tables B.3a and B.3b;

(5) All scalar variables must precede any multi-level (e.g., tower) variables;

(6) The file must be ASCII and it must be in a form that can be read using Fortran FORMAT statements.

When specifying the multi-level variables, such as observations from an instrumented tower, the variable name includes a two-character prefix that identifies the atmospheric quantity and a two-character suffix that identifies the level. For example, height, temperature and wind speed from the first level would appear as HT01, TT01 and WS01 on the VARS keyword statement, from the second level as HT02, TT02, WS02, and so on.

The *Fortran_format* is a character string that AERMET uses directly in the program. Hence, the string must comply with all the rules of Fortran for creating a format statement. The format must begin with an open parenthesis and end with a closing parenthesis. The list-directed format specifier (an asterisk, *) cannot be used because the string "(*)" is not recognized by the compilers (the parentheses are required). Any book on standard Fortran can provide guidance on constructing a format statement.

Blanks in the format specification must be avoided because AERMET recognizes both blanks and commas as field delimiters on keyword statements. With the presence of the commas in the format, blanks in the format specification (possibly to improve readability of the format) will cause an error in processing the keyword statement.

Not all of the variables present in the on-site data file need to be read. Any superfluous data can easily be skipped over using the X, T and / edit descriptors. However, *the same format used to read the original on-site data file is also used to write the QA file*. If some variables or entire lines of data are skipped, then the QA output file will contain corresponding blank fields and/or blank lines.

Once the variables and formats have been defined, the user does not need to specify them for any subsequent AERMET runs (e.g., for Stage 3 processing) as long as the information remains in the file header records. AERMET reprocesses these records, if present, whenever the data are used in subsequent processing, saving the user the time required to setup that portion of a runstream file and avoiding introducing errors on these tow keyword statements.

3.5.3 Processing a Subset of the Data - XDATES

The amount of data processed can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to process and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces before or after the slash (/). The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword statement is processed.

3.5.4 Identifying the Station - LOCATION

AERMET requires location information about the site where the measurements are taken. The LOCATION keyword statement specifies the station identifier, latitude and longitude, and a time adjustment factor. The syntax and type are:

Syntax:	LOCATION *site_id site_lat/long site_long/lat tadjust*
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the site. Since data are not extracted from archived data, there is no requirement to specify an identifier for that purpose. Here, the *site_id* can be used to identify the site in the output files (reports and from Stage 3).

The measurement site latitude and longitude can be entered in either order because the user must include a suffix on each: an N or S with the latitude and W or E with the longitude. AERMET interprets the suffix and retains the information in the correct variable name. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N". AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north/south and east/west. The site latitude and longitude for the ONSITE pathway are not used for any purpose at this time. They are simply another way to identify the site being processed.

The final parameter for this keyword, *tadjust*, is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The adjustment factor is subtracted from the reported hour. The default value for *tadjust* is zero. Since there is no standard format for on-site data, the time reported could be relative to any time frame. One time frame the user should verify is if the data are reported in local daylight time. If this is the case, then *tadjust* should be specified as 1.

3.5.5 How good are the data? - QAOUT

One of the purposes of AERMET is to assess the quality of the data to insure that high quality data are used in estimating the dispersion parameters. The quality assessment (QA) is performed by including the QAOUT keyword statement in a runstream file. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2), Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters. For one year of data with three levels and six variables (including the heights), the size of the output file is approximately 1.7 Mb.

As suggested by the type of keyword, quality assessment is an optional process. In other words, the user does not have to perform a quality assessment prior to merging the data. However, we strongly recommend this step to identify any possible problems with the data that are used to derive the dispersion parameters.

Presently, AERMET's capabilities in this area are limited to verifying the values of the on-site data are not outside a range of acceptable values and keeping track of the number of missing values. These checks operate one observation period at a time, i.e., variations over a period of time are not checked.

On-site data may be reported more frequently than once per hour (see the OBS/HOUR keyword discussed below). For observations more frequent than once per hour, the QA procedures operate on the subhourly data. There is no QA on the one-hour averaged data.

When a quality assessment is performed on the on-site data, several of the variables are automatically tracked (audited) and included in a summary of the QA process. These variables are: temperature, wind speed and wind direction. The value of each variable at each level is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. The number of times the variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file defined by the REPORT keyword. Each time a value is missing or violates one of the bounds, a two-line message is written to the message file defined on the ERRORS keyword statement, which identifies the variable, the violation, and data and time of occurrence.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator for each variable. These values can be changed by the user through the use of the RANGE keyword, as described below. The user can QA additional variables by using the AUDIT keyword.

3.5.6 Adding On-Site Variables to the QA - AUDIT

There are three on-site variables that are tracked by default during a QA. The user can track additional variables for a particular AERMET run by specifying the variable name on an AUDIT keyword statement. The syntax and type for this keyword are:

Syntax:	AUDIT *osname*1 ... *osname*n
Type:	Optional (Stage 1), Repeatable

where *osname*1, ..., *osname*n are the upper air variable names as defined in Table C.3. As many variable names can be specified on a single keyword statement that will fit within the 80-character limitation of a keyword statement. Since this keyword is repeatable, more than one AUDIT keyword statement can be used to define additional variables.

3.5.7 <u>Changing the Default Values for the QA</u> - RANGE

The user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *osname lower_bound* <[=] *upper_bound missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *osname* is the on-site variable as defined in Table C.3, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value code. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified on with this keyword even if a parameter is not changing.

Unlike data for the SURFACE and UPPERAIR pathways, the on-site data are written to the output file as real and integer values because of the variety of data and user-defined formats. The exceptions to this rule are the surface variables shared with the SURFACE pathway.

3.5.8 Reducing the Number of QA Messages - NO_MISSING

As mentioned in the discussion for the QAOUT keyword, a two-line message is written to the message file (defined on the ERRORS keyword statement) every time a bound is violated or a value is missing. If one variable that is tracked for reporting is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message file, the NO_MISSING keyword statement can be included during a QA. The syntax and type are:

Syntax:	NO_MISSING *osname*1 ... *osname*N
Type:	Optional (Stage 1), Repeatable

where *osname*1, ..., *osname*N are the variable names of the weather variables to omit from the message file. The number of missing values is still tallied and reported in the summary file.

3.5.9 Site Characteristics - FREQ_SECT, SECTOR, and CHARS

Surface conditions at the measurement site, referred to as the site characteristics, influence dispersion parameter estimates. Obstacles to the wind flow, the amount of moisture at the surface and reflectivity of the surface all affect the estimates. These influences are quantified through the surface albedo, Bowen ratio and roughness length (z_0), and are defined for AERMET through the three keywords FREQ_SECT, SECTOR and CHARS. These three keywords must appear together in a runstream file. These characteristics are not needed until Stage 3, but may be included in any input runstream file for any stage of processing. The syntax, type and a discussion of each follows.

Syntax:	FREQ_SECT *frequency number_of_sectors*
Type:	Optional (Stage 1, 2 or 3), Nonrepeatable, Reprocessed
Order:	This keyword must appear before SECTOR and CHARS

This keyword defines how often these characteristics change (the *frequency*), or alternatively, the period of time over which these characteristics remain constant, and the number of nonoverlapping sectors into which the 360°-compass directions are divided (*number_of_sectors*). This keyword can appear only once and **must appear before the SECTOR and CHARS keywords**.

The *frequency* can be ANNUAL, SEASONAL or MONTHLY, corresponding to 1, 4, or 12 periods, respectively. ANNUAL and MONTHLY are straightforward: the site characteristics are the same for all months of the year, and the site characteristics vary from month to month. When SEASONAL is specified, then the site characteristics are distributed by month as follows:

1	Spring	March, April, May
2	Summer	June, July, August
3	Autumn	September, October, November
4	Winter	December, January, February

The number before the season represents the frequency index that is specified for that season on the CHARS keyword statement.

A minimum of 1 and a maximum of 12 can be specified for the *number_of_sectors*. If more sectors than 12 is required, then the user will have to modify the parameter NWDS in MASTER.INC and recompile and relink the AERMET software.

Syntax:	SECTOR *sector_index beginning_direction ending_direction*
Type:	Optional (Stage 1), Repeatable, Reprocessed

A SECTOR statement defines the beginning and ending wind direction sector. One sector is defined per keyword statement, with the *sector_index* linking a specific sector to a set of site characteristics. The sectors are defined clockwise, they must cover the full circle, and these must be defined so that the end of one sector corresponds to the beginning of another. The *beginning_direction* is considered part of the sector, while the *ending_direction* is excluded from the sector. The directions reference the direction from which the wind is blowing. A sector can cross through north (e.g., 345 - 15) or can start or stop at north (e.g., 0 - 30 or 270 - 360). AERMET will verify that the entire 360° circle is covered, and that there are no gaps in the definition. See Section 5 for a detailed discussion on defining the wind direction sector and the associated surface characteristics.

Syntax:	CHARS *frequency_index sector_index albedo Bowen roughness*
Type:	Optional (Stage 1), Repeatable, Reprocessed

The site characteristics are specified on CHARS keyword statements, with one statement for each combination of time period and wind sector. The *frequency_index* varies from one to the number of time periods corresponding to the frequency defined on the FREQ_SECT keyword. The *sector_index* varies from one to the number of sectors defined on the FREQ_SECT keyword. These indices are followed by the albedo, Bowen ratio and roughness length for the frequency/sector combination. If the maximum frequency (MONTHLY) and number of sectors were defined, then it would require 144 (12 frequencies and 12 sectors) CHARS statements to completely define the site characteristics.

The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for thick deciduous forests to 0.90 for fresh snow. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux and is used for determining planetary boundary layer parameters for convective conditions. While the diurnal variation of the Bowen ratio may be significant, the Bowen ratio usually attains a fairly constant value during the day. Midday values of the Bowen ratio range from 0.1 over water to 10.0 over desert. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from less than 0.001 m over a calm water surface to 1 m or more over a forest or urban area.

Default values typical of cultivated land with average moisture content are in AERMET, but are not recommended because they are very general and not likely to apply to the location where the measurements are taken. These defaults are:

Frequency:	annual
Number of sectors:	1
Sector definition:	0-360
Albedo, Bowen ratio, Roughness length:	0.25, 0.75, 0.15 meters

In most applications the user should override these default values. Tables 3.1 - 3.3, from Paine (1987), provide some guidance on specifying these values by land use type and season.

In these tables, the seasons do not correspond to a particular group of months, but more on latitude and the annual vegetative growth cycles. Spring refers to the period when vegetation is emerging or partially green and applies to the 1-2 months after the last killing frost. The term summer applies to the period when vegetation is lush. The term autumn refers to the period of the year when freezing conditions are common, deciduous trees are leafless, soils are bare after harvest, grasses are brown and no snow is present. Winter conditions apply to snow-covered surfaces and subfreezing temperatures. For example, March in the southern United States is spring, but it is still winter in much of New England.

Table 3.1. Albedo of Natural Ground Covers by Land-Use and Season.

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.12	0.10	0.14	0.20
Deciduous Forest	0.12	0.12	0.12	0.50
Coniferous Forest	0.12	0.12	0.12	0.35
Swamp	0.12	0.14	0.16	0.30
Cultivated Land	0.14	0.20	0.18	0.60
Grassland	0.18	0.18	0.20	0.60
Urban	0.14	0.16	0.18	0.35
Desert Shrubland	0.30	0.28	0.28	0.45

The Bowen ratio for winter in the next three tables depends on whether a snow cover is present continuously, intermittently or seldom. For seldom snow cover, the values between autumn and winter may be more applicable; for continuous snow cover, the values for winter are applicable. For bodies of water, it is assumed that the surface is frozen.

Table 3.2a. Daytime Bowen Ratio by Land Use and Season for Dry Conditions.

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	2.0
Deciduous Forest	1.5	0.6	2.0	2.0
Coniferous Forest	1.5	0.6	1.5	2.0
Swamp	0.2	0.2	0.2	2.0
Cultivated Land	1.0	1.5	2.0	2.0
Grassland	1.0	2.0	2.0	2.0
Urban	2.0	4.0	4.0	2.0
Desert Shrubland	5.0	6.0	10.0	10.0

Table 3.2b. Daytime Bowen Ratio by Land-Use and Season for Average Moisture Conditions.

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	1.5
Deciduous Forest	0.7	0.3	1.0	1.5
Coniferous Forest	0.7	0.3	0.8	1.5
Swamp	0.1	0.1	0.1	1.5
Cultivated Land	0.3	0.5	0.7	1.5
Grassland	0.4	0.8	1.0	1.5
Urban	1.0	2.0	2.0	1.5
Desert Shrubland	3.0	4.0	6.0	6.0

Table 3.2c. Daytime Bowen Ratio by Land-Use and Season for Wet Conditions.

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	0.3
Deciduous Forest	0.3	0.2	0.4	0.5
Coniferous Forest	0.3	0.2	0.3	0.3
Swamp	0.1	0.1	0.1	0.5
Cultivated Land	0.2	0.3	0.4	0.5
Grassland	0.3	0.4	0.5	0.5
Urban	0.5	1.0	1.0	0.5
Desert Shrubland	1.0	5.0	2.0	2.0

Table 3.3. Surface Roughness Length, in Meters, by Land-Use and Season.

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	1.00	1.30	0.80	0.50
Coniferous Forest	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05
Cultivated Land	0.03	0.20	0.05	0.01
Grassland	0.05	0.10	0.01	0.001
Urban	1.00	1.00	1.00	1.00
Desert Shrubland	0.30	0.30	0.30	0.15

3.5.10 An Alternate Specification of Measurement Heights - HEIGHT

The measurement heights for the multi-level data may or may not appear explicitly as one of the variables in the data file. These heights (in meters) can be entered on a HEIGHT statement in order from lowest to highest. The syntax and type for this keyword are:

Syntax:	HEIGHTS *height*1 ... *height*n
Type:	Optional if height information is in data; otherwise mandatory (Stage 1), Repeatable, Reprocessed

This statement can also be used to override the height variables that may be present in the data file. For example, if the heights in the data file are 10.0, 50.0 and 100.0, but the user knows that the heights are really 9.0, 50.0 and 100.0, rather than modify the data file, the HEIGHTS keyword can be used to rectify the problem.

3.5.11 Temperature Differences - DELTA_TEMP

In addition to measuring ambient temperature directly, an on-site data program may measure differences in temperature. These measurements can be either between the levels where the ambient temperature is measured or independently of these levels. Temperature difference near the surface can be used to infer sensible heat flux. Measured temperature differences are not the same as the ambient temperature difference between two levels. A true temperature difference utilizes an instrument, such as a thermocouple, that couples two levels of data, whereas ambient temperature at two levels most likely is measured by two independent instruments, as with wind vanes.

The ONSITE data pathway has provisions for up to three temperature differences, which can be defined through the three scalar variables DT01, DT02 and DT03. These values are treated as scalar variables because the height at which a single difference is applied is most likely between two levels of ambient temperature data. The heights that define the temperature difference cannot be entered directly through the VARS and FORMAT keyword statements (recall that the same information must appear at all levels in those keywords). The special keyword statement DELTA_TEMP defines the two levels that comprise the temperature difference. The syntax and type are:

Syntax:	DELTA_TEMP *index lower_height upper_height*
Type:	Optional (Stage 1), Repeatable, Reprocessed

Each statement includes an index that corresponds to the temperature difference represented by the *lower_* and *upper_heights*. The index can range from one to three.

At present, none of the processing options in Stage 3 utilizes temperature difference. Methods may be incorporated in future versions of AERMET that require these values, and the structure for processing such data will already exist.

3.5.12 Threshold Wind Speeds - MIN_WIND

The minimum wind speed required to detect air flow varies from anemometer to anemometer. For NWS data, this speed is assumed to be 1 m/s. However, on-site measurement programs may use instruments that can detect speeds below this value. The minimum detectable (threshold) wind speed of the on-site anemometer can be specified on the MIN_WIND statement. The minimum speed can only be redefined to a lower value. The syntax and type for this keyword are:

Syntax:	MIN_WIND *threshold_wind_speed*
Type:	Optional (Stage 1), Nonrepeatable, Reprocessed

The default is 1 ms^{-1}. When processing on-site data, if the wind speed is less than the threshold value, then the wind speed is set to 1 ms^{-1} and the wind direction is set to the last valid wind direction. If the on-site wind speed is greater than the threshold value and less than 1 ms^{-1}, then the wind speed is set to 1 ms^{-1} and the wind direction is unchanged.

3.5.13 Multiple Observation Periods for Each Hour - OBS/HOUR

On-site data may include more than one observation period each hour. If the data include more than one observation period each hour, the user must supply an OBS/HOUR statement to specify the number of observations that AERMET should expect each hour. AERMET currently allows up to 12 observation periods per hour and will calculate the average over all periods within the hour to produce an hourly average. For one observation period per hour, this keyword statement is optional. The syntax and type for this keyword are:

Syntax:	OBS/HOUR *n_obs*
Type:	Mandatory for data with more than 1 observation per hour (Stage 1), Nonrepeatable

All variables specified on the VARS keyword statements must be reported at the same number of observations per hour, e.g., one variable cannot be reported once per hour and the remaining variables reported four times per hour. An option to work around this restriction would be for the user to duplicate the value for each observation period such that the "average" is equal to the value reported.

AERMET will calculate the average of a variable only if at least half of the number of observations present for that hour are non-missing, otherwise a missing value code is written for the variable. For most variables the hourly value is computed as the arithmetic mean. However, averages related to the wind are handled somewhat differently. The hourly wind direction is computed according to the method in the on-site meteorological program guidance document (EPA, 1987) to account for any 0°-to-360° crossover. A wind speed for a (subhourly) period that is less than the threshold speed is given a value of one half the threshold speed (see the discussion above for MIN_WIND) and wind direction is treated as missing before computing an arithmetic mean. For the standard deviations of the wind fluctuations, hourly values are computed from the root mean square of the subhourly values following the on-site meteorological guidance (EPA, 1987).

3.6 MERGE PATHWAY

This pathway is referred to as Stage 2 processing, which involves combining the different sources of data into one file composed of blocks of 24-hour data. This is an intermediate, but necessary, step between extracting and QAing archived data and estimating dispersion parameters. As such, there are only three keywords related directly to this pathway.

The beginning of this pathway is identified by the MERGE keyword statement, which has the syntax and type as follows:

Syntax:	MERGE
Type:	Mandatory, Nonrepeatable

There are no parameters associated with this keyword.

3.6.1 The Output File - OUTPUT

As the data are combined/merged together in 24-hour blocks, the result is written to an ASCII output file. The file is specified on the OUTPUT keyword statement. The syntax and type for OUTPUT are:

Syntax:	OUTPUT *merged_data_filename*
Type:	Mandatory, Nonrepeatable

The *merged_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

The input data are provided by the three data pathways through the QAOUT keyword when such data are available. For example, if there are no on-site data to merge, then only the QAOUT keyword statements for the SURFACE and UPPERAIR pathways are required. If all threes data types are merged and there are six variables at three levels for the onsite data, then the output file will be about 6 Mb. If only NWS data are merged, then the output file will be about 3.2 Mb.

3.6.2 Merging a Subset of the Data - XDATES

As with the other data pathways, the amount of data merged can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be merged. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Optional, Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces before or after the slash (/). The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword statement is processed.

If the XDATES keyword is omitted, then the preprocessor searches all the input files to this stage and determines the earliest date in the files. AERMET then merges the data beginning with this date and continuing for 367 days or until the data are exhausted.

3.7 METPREP PATHWAY

This pathway is also referred to as Stage 3. It is the heart of the AERMET preprocessor, where the parameters are estimated for dispersion models. The processing is the third and final step in the sequence of steps that began with extracting data from archived data files. Unlike the processing up to this point, which was performed with one executable, this stage is a separate executable program.

The beginning of this pathway is identified by the METPREP keyword statement, which has the syntax and type as follows:

Syntax:	METPREP
Type:	Mandatory, Nonrepeatable

There are no parameters associated with this keyword.

Several of the keywords seen on the previous pathways are also used on this pathway in an identical manner.

3.7.1 The Input Data File - DATA

Like all the previous stages, this stage requires input data. The data file generated by the Stage 2 processing - merging data - is the necessary file and is defined on the DATA keyword statement. The syntax and type are:

Syntax:	DATA *merged_data_filename*
Type:	Mandatory, Nonrepeatable

The *merged_data_filename*, which is an ASCII file, must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

3.7.2 Output from Stage 3 - OUTPUT and PROFILE

AERMET Stage 3 processing creates two output files. The first of these files contains the dispersion parameters and some of the data that went into computing these parameters.

These parameters are stored in the file defined on the OUTPUT keyword statement, with the following syntax and type:

Syntax:	OUTPUT *parameter_filename*
Type:	Mandatory, Nonrepeatable

The *parameter_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters. For one year of data, the size of this file is approximately 1 Mb.

There is one record for each hour processed. These data are written with at least one space between each element, i.e., the data are free format. The contents of this file are:

Year
Month (1 - 12)
Day (1 -31)
Julian day (1 - 366)
Hour (1 - 24)
Sensible heat flux (W m^{-2})
Surface friction velocity, u_* (ms^{-1})
Convective velocity scale, w_* (ms^{-1})
Vertical potential temperature gradient in the 500 m layer above the planetary boundary layer
Height of the planetary boundary layer (m)
Height of stable boundary layer (m), currently not used by AERMOD
Monin-Obukhov length, L (m)
Surface roughness length, z_0 (m)
Bowen ratio
Albedo
Wind speed (ms^{-1}) used in the computations
Direction (degrees) the wind is blowing from and corresponds to the wind speed above
Height at which the wind above was measured (m)
Temperature (K) used in the computations
Height at which the temperature above was measured (m)

A second file is written during Stage 3 - a file of profile data as identified on the PROFILE keyword statement. The syntax and type are:

Syntax:	PROFILE *profile_filename*
Type:	Mandatory, Nonrepeatable

The *profile_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this filename is 48 characters.

There are one or more records for each hour processed. The data are written with at least one space between each element, i.e., the data are free-format. The exact format of this file can be found in Appendix C. The contents of this file are:

Year
Month (1 - 12)
Day (1 -31)
Hour (1 - 24)
Measurement height (m)
Top flag = 1, if this is the last (highest) level for this hour,
0, otherwise
Direction the wind is blowing from for the current level (degrees)
Wind speed for the current level (ms^{-1})
Temperature at the current level (K)
Standard deviation of the wind direction fluctuations, σ_θ (degrees)
Standard deviation of the vertical wind speed fluctuations, σ_w (ms^{-1})

The data in this latter file are the profiles of on-site meteorological data that are entered through QAOUT keyword statement (whether or not the data were actually QA'd) on the ONSITE pathway if on-site data are available. If there are no data for a particular variable for an hour, either at one or all levels, then the field is filled with a missing value indicator. Only the variables listed above are in this output file. Additional variables that may be specified on the ONSITE pathway (e.g., the standard deviation of one of the horizontal components of wind) are not written to this file.

AERMET was designed to be able to perform these dispersion parameter calculations with NWS data only, i.e., no on-site data. In this case, the NWS winds and temperature are used to create a one-level "profile". The NWS data are also used in the event that all the variables at all levels for a given hour are missing.

For one year of data with three levels of on-site data, the size of this file is 1.5 Mb. If NWS data are used to create the one-level profile, the size of the file is reduced to 0.5 Mb.

3.7.3 Choosing a Dispersion Model - MODEL

Although AERMET currently only estimates parameters for the AERMOD dispersion model, it is designed with the capability to estimate parameters for other dispersion models. The MODEL keyword statement informs AERMET which model for which to process the data. The syntax and type are:

Syntax:	MODEL *model_name*
Type:	Optional, Nonrepeatable

where *model_name* identifies the dispersion model. For this version of AERMET, the only model supported is AERMOD. Therefore, the AERMOD model is the default model and this keyword is optional.

3.7.4 Identifying the Site - LOCATION

AERMET requires location information regarding the site for which the data are being prepared. The LOCATION keyword statement is identical in all respects to its usage on other pathways: the site identifier, latitude and longitude, and a time adjustment factor. The syntax and type are:

Syntax:	LOCATION *site id source lat/long source long/lat tadjust*
Type:	Mandatory, Nonrepeatable
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the site. This field is simply a means to identify the site and is not used otherwise.

Unlike the SURFACE, UPPERAIR and ONSITE pathways, the latitude (*lat*) and longitude (*long*) on the METPREP pathway is very important. These coordinates should reflect the location of the source, i.e., the location where the dispersion model is to be applied. These coordinates are used in the estimates to compute sunrise/sunset and solar elevation, which are used in the surface flux and boundary layer height calculation. It is important to accurately identify the location of the source. Latitude and longitude can be entered in either order because the user must include a suffix on each: an N or S with the latitude and W or E with the longitude. AERMET interprets the suffix and retains the information in the correct variable name. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N". AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north/south and east/west.

The final parameter for this keyword, *tadjust*, is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The default value for *tadjust* is zero. Currently, this parameter is not used in any of the computations.

3.7.5 Instrumentation Heights for NWS Data - NWS_HGT

When various parameters are computed for the dispersion models, the height of the instruments is usually required. With on-site meteorological data, the heights of the measurements are generally available and entered through the VARS or HEIGHTS keywords on the ONSITE pathway. If there are no on-site data, or for isolated hours when there are on-site data, then NWS data are substituted for the computations. However, instrument height is not reported. The NWS_HGT keyword statement is used to provide this information. The syntax and type are:

Syntax:	NWS_HGT *variable_name instrument_height*
Type:	Mandatory, Repeatable

The *variable_name* specifies which meteorological instrument is being referenced and is followed by the *instrument_height* in the appropriate units. Currently, there is only one secondary keyword: WIND. The height of the wind instrument (anemometer) can range anywhere from about 20 feet (6.7 meters) to 30 feet (9.1 meters). The former has been the standard height for many years at NWS sites. More recently, measurements at some NWS sites have been raised to the latter value. The *Local Climatological Data Annual Summaries* available from NCDC contain a historical record of instrumentation sites and heights for the stations in the five volume set. The user should consult a reference such as the Annual Summaries prior to running Stage 3. AERMET expects the anemometer height in meters.

3.7.6 Processing a Subset of the Merged Data - XDATES

Like all previous pathways, the amount of data processed can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be merged. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Optional, Nonrepeatable

YB, MB and DB are the beginning year, month and day, respectively, of the data to extract and YE, ME, and DE are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces before or after the slash (/). The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword statement is processed.

If the XDATES keyword is omitted, then the AERMET processes all the data in the input file specified on the DATA keyword statement.

3.7.7 Processing Options - METHOD

The METHOD keyword statement is used to define particular methods for processing the input data. This keyword requires a secondary keyword to identify the particular meteorological variables that are affected and the option to use. The syntax and type are:

Syntax:	METHOD *atmos_variable parameter*
Type:	Optional, Repeatable

Currently, there is only one *atmos_variable* for the METHOD keyword in AERMET. It is WIND_DIR, which affects the way in which the reference wind direction is handled when only NWS data are available. The WIND_DIR keyword has two parameters associated with it, RANDOM and NWS_10.

National Weather Service wind directions are reported to the nearest 10° (e.g., a direction of 164° would be reported as 16). In PCRAMMET, a first-generation meteorological preprocessor used for models such as the Industrial Source Complex Short Term (ISCST2) model, the NWS wind directions are adjusted to yield a direction to the nearest degree. This procedure continues in AERMET, and is accomplished by adding the parameter RANDOM after the secondary keyword.

Randomization is accomplished by using a single-digit random number, with a separate random number predefined for each hour of the year. This array of numbers is static and has become an EPA standard. The random number is added to the wind direction (which is first multiplied by 10) and 4 is subtracted from the result to yield a direction to the nearest degree. The array of random numbers is internal to AERMET; therefore, a separate file of these standard random numbers is not necessary.

If the user does not want to randomize the wind direction, then this keyword can be omitted, i.e., the default is to not randomize the wind direction. However, if the user wants a reminder as to how the data were processed, a parameter has been provided that the user can specify: NWS_10.

This keyword has no effect when on-site data are available for the hour. It is assumed that the on-site wind direction is reported to the nearest degree and does not need randomizing.

While simple in its current form, enhancements to AERMET could require defining additional *second_keys*. For example, in MPRM, a similar keyword controls which method for estimating stability will be used. Other possible applications include a choice of methods for estimating surface fluxes. Hence, this keyword is repeatable, but will be practical only when additional *second_keys* are implemented.

3.7.8 Tracking Processing Errors - TRACE

Occasionally, the results from the Stage 3 processing may not appear to make any sense. For example, the heat flux could be fluctuating erratically on a sunny afternoon in the summer. When the results do not appear to be correct, it is useful to obtain additional information regarding the processing. The TRACE keyword provides a way to obtain that information. The syntax and type are:

Syntax:	TRACE
Type:	Optional, Nonrepeatable

This keyword does not require any parameters.

The TRACE keyword does not provide values from intermediate calculations. Rather, additional messages regarding the processing are written to the message file (defined on the ERRORS keyword statement on the JOB pathway). One or more of these messages may enable the user to determine if a problem exists, and if one does exist, what is causing the problem.

3.7.9 Listing the Results - LIST

The LIST keyword provides a way to write the output meteorology to the summary file defined on the REPORT keyword of the JOB pathway. The syntax and type are:

Syntax:	LIST
Type:	Optional, Nonrepeatable

This keyword does not require any parameters.

For AERMOD, the default (and only) dispersion model currently supported by AERMET, this keyword is not useful. The primary intent for this keyword is if the output files are binary rather than ASCII, then a means exists to print the meteorological data without requiring the user to write a separate program to read the binary data and write a separate ASCII file. If AERMET is ever modified to output binary data for a dispersion model, then this keyword can be utilized for its intended purpose.

SECTION 4

OUTPUT REPORTS

This section describes the content of the two types of reports generated by AERMET for the various pathways. These reports were generated using the runstreams of Section 2. Only Stage1 and Stage 2 are presented here. The reports for Stage 3 are discussed at the end of Section 2.

The message file, defined by the ERRORS keyword statement on the JOB pathway, contains all the error, warning and informational messages issued by AERMET. Most of these messages are the result of problems with interpreting command statements or processing data files. Referring to Figure 4.1, the value in the first field represents a counter and its interpretation depends on the current processing. If the input runstream file is being processed, the value represents the record number in runstream file. If data are being processed, the value represents the Julian day and hour for which the message originated. If the statement does not relate to runstream or data processing (e.g., an informational message), then a zero may appear in this field. This code is followed by the pathway that is being processed. The pathway is followed by three columns that represent a code used by AERMET to summarize the number of messages in tabular form. If an 'E' appears, then a fatal error was encountered; an 'I' indicates an informational message, 'W' for a warning, and 'Q' refers to a message from the QA process in Stage 1. The two-digit number indicates a type of error within a specific pathway. Appendix D contains a list of all the message codes issued by AERMET with a brief explanation of each. The error code is followed by the name of the subroutine from which the message originated. This name is followed by a message that provides some additional information on the nature of the message. A complete description of these messages is in Appendix D.

The second report file, defined by the REPORT keyword statement on the JOB pathway, summarizes the actions performed by AERMET and provides a summary table of the messages as well as repeating the warning ('W') and error ('E') messages.

4.1 SURFACE PATHWAY: EXTRACT AND QA

The messages generated as a result of extracting and performing a QA on NWS hourly surface observations (see Figure 2.1 for the runstream) is shown in Figure 4.1. The first nine messages are informational messages as denoted by the 'I' in the first column of the third field. The first message indicates that an end of file was encountered during the processing of the runstream file (on the JOB pathway) while trying to read the 11th record in the runstream (indicated by the 11 in the first field). This is a standard message that appears in a message file. The second through seventh messages indicate what processing will not be performed based on the omission of pathways and keywords in the runstream. The eighth message indicates the start of data extraction and the ninth message indicates that 240 hourly observations were extracted from the archive file. The user can use this information to verify that the correct number of observations were retrieved; in this case, 10 days * 24 observations per day = 240 observations.

Following the data extraction, a quality assessment was performed, with the violations reported. However, there were no upper or lower bound violations, nor were there any missing data, but there were 20 hours with calm winds (speed = 0) for the dates and hours shown. The final message indicates that the QA processed 240 observations (hours). Note that for these QA messages, the Julian day concatenated with the hour of the observation appears at the beginning of the record and the Gregorian date and hour appear at the end of the message.

```
  11 JOB        I19  SETUP: FOUND "END OF FILE" ON UNIT  5

   0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR UPPERAIR

   0 JOB        I11   TEST: SUMMARY: NO QA FOR UPPERAIR

   0 JOB        I12   TEST: SUMMARY: NO MERGE FOR UPPERAIR

   0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR ONSITE

   0 JOB        I11   TEST: SUMMARY: NO QA FOR ONSITE

   0 JOB        I12   TEST: SUMMARY: NO MERGE FOR ONSITE

   0 SURFACE   I40  SFEXT: *** SURFACE OBSERVATION EXTRACTION ***
 240 SURFACE    I49  SFEXT:  240 SURFACE RECORDS EXTRACTED

6202 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/02/02

6203 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/02/03

6204 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/02/04

6205 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/02/05

6206 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/02/06

6207 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/02/07

6319 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/03/19

6321 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/03/21

6600 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/00

6601 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/01

6602 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/02

6603 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/03

6604 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/04

6605 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/05

6606 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/06

6607 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/06/07

6821 SURFACE    CLM SFQASM: CALM WINDS ON 88/03/08/21
```

Figure 4.1. Listing of the message file for NWS surface data.

```
1        AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                    TODAY'S DATE AND TIME: 16-JUL-95 AT 14:47:53
                    INITIAL PROCESSING ON RAW METEOROLOGICAL DATA


                   STATUS REPORT PRIOR TO BEGINNING PROCESSOR RUN


  1.  REPORT FILE NAMES

       ERROR MESSAGES: SFCERR.LIS
       SUMMARY OF RUN: SFCRPT.LIS


  2.  UPPER AIR DATA

       THE PROCESS(ES) AERMET ANTICIPATES TO PERFORM ARE
        NONE, NO DATA TO BE PROCESSED ON THIS PATH



  3.  NWS SURFACE DATA

       SITE ID    LATITUDE(DEG.)   LONGITUDE(DEG.)   CONVERSION TO LST
         14735       42.75N            73.80W                0

       THE PROCESS(ES) AERMET ANTICIPATES TO PERFORM ARE
        EXTRACT AND QUALITY ASSESSMENT

       EXTRACT INPUT -     OPEN: S1473588.144

       EXTRACT OUTPUT-     OPEN: SFCEXT.DSK

       QA OUTPUT     -     OPEN: SFCQA.DSK


       THE EXTRACT DATES ARE:    STARTING:  1-MAR-88
                                   ENDING: 10-MAR-88


  4.  ON-SITE DATA

       THE PROCESS(ES) AERMET ANTICIPATES TO PERFORM ARE
        NONE, NO DATA TO BE PROCESSED ON THIS PATH
```

Figure 4.2a. Summary file for the NWS surface data.

The summary of the processing of the NWS surface observations is shown in Figures 4.2a - 4.2c.

```
1        AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                   VERSION 1.10

                        TODAY'S DATE AND TIME: 16-JUL-95 AT 14:47:56
                        INITIAL PROCESSING ON RAW METEOROLOGICAL DATA

                 ***********************************************************
                 ***                JOB TERMINATED NORMALLY              ***
                 ***********************************************************


                      **** AERMET MESSAGE SUMMARY TABLE ****

            0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89
 TOTAL

 -----------------------------------------------------------------------

    JOB
      E     0       0       0       0       0       0       0       0
 0
      W     0       0       0       0       0       0       0       0
 0
      I     0       7       0       0       0       0       0       0
 7

    SURFACE
      E     0       0       0       0       0       0       0       0
 0
      W     0       0       0       0       0       0       0       0
 0
      I     0       0       0       0       3       0       0       0
 3
      Q     0       0       0       0       0       0       0       0
 0

 -----------------------------------------------------------------------
           0      7      0      0      3      0       0       0      10

        ****   WARNING MESSAGES ****

               ---  NONE  ---


        ****    ERROR MESSAGES   ****

               ---  NONE  ---
```

Figure 4.2b. Continuation of the summary file for NWS surface data.

```
1       AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                     TODAY'S DATE AND TIME: 16-JUL-95 AT 14:47:56

               *******************************************************
               ***                JOB TERMINATED NORMALLY          ***
               *******************************************************

                         **** SUMMARY OF THE QA AUDIT ****

 SURFACE DATA                  |------VIOLATION SUMMARY------|      |-----TEST
VALUES-----|
                   TOTAL     #      LOWER  UPPER      %       MISSING   LOWER
UPPER
                   # OBS  MISSING   BOUND  BOUND  ACCEPTED      FLAG    BOUND
BOUND
          PRES      240            0      0       0     100.00     99999.0,
9000.0,10999.0
        TS         240       0      0      0     100.00        99.0,    0.0,
10.0
          KC       240       0      0      0     100.00        99.0,    0.0,
10.0
        TMPD       240       0      0      0     100.00       999.0, -300.0,
350.0
        WD16       240       0      0      0     100.00        99.0,    0.0,
36.0
        WIND       240       0      0      0     100.00     -9999.0,    0.0,
500.0

 NOTE: TEST VALUES MATCH INTERNAL SCALING APPLIED TO VARIABLES
      (SEE APPENDIX B OF THE USER'S GUIDE)

        THE FOLLOWING CHECKS WERE ALSO PERFORMED FOR THE SURFACE QA

        OF   240 REPORTS, THERE WERE

             20 CALM WIND CONDITIONS (WS=0, WD=0)

              0 ZERO WIND SPEEDS WITH NONZERO WIND DIRECTIONS

              0 DEW-POINT GREATER THAN DRY BULB TEMPERATURES

        THE TIMES OF THESE OCCURRENCES CAN BE FOUND IN THE MESSAGE FILE

        WITH QUALIFIERS CLM, WDS, TDT (RESP.)
```

Figure 4.2c. Continuation of the summary file for NWS surface data.

The summary file is one file; it is divided into three parts here for the discussion but also represents the three pages that would be printed if the summary was directed to a printer rather than a file when AERMET was run. Fortran carriage controls are used to format the summary reports, thus the page breaks; if the output is written to a file and then printed, the carriage controls are ignored and appear as a part of the printed text (as they do here at the top of each figure in column 1).

At the top of each figure (each "page"), a banner is printed with the AERMET name, version and processing date and time. In Figure 4.2a, this banner is followed by a summary of the file names on the JOB pathway (item 1) and processing that is anticipated by pathway (items 2-4). Notice that there are no upper air and on-site data to be processed, and corresponds to the informational messages (nos. 2-7) in Figure 4.1. A tabular summary of the messages by pathway and message code appears in Figure 4.2b, which would correspond to the second printed page. Notice that the calm wind conditions reported in the message file are not included in the table entries. Only the first nine messages and last message are summarized here, i.e., only the 'E', 'W', 'Q' and 'I' codes. The final figure in this series (Figure 4.2c) contains a tabular summary of the data quality assessment, and corresponds to the

third printed page. The variables that were audited are listed on the left side of the table. The variable names correspond to the names in Table B-2 of Appendix B. The unusual appearance of the names TS and KC are due to the QA of the concatenated variable TSKC - the total and opaque cloud cover, respectively. The first two characters represent the first part of the value (total cloud cover) and the second pair of characters represent the second part of the value (opaque cloud cover). In this example, all the values "passed" the QA (the central portion of the table) - there were no missing data and no violations of the lower or upper bounds. The limits the observations were compared against are shown on the right side of the table (designated by TEST VALUES). As the note indicates, the test values have the multipliers (if any) applied. Below the table is a short report on some additional QA that was performed. It is here where the calm winds are summarized. Additionally, the number of occurrences of a zero wind speed with a nonzero wind direction or a dew point greater than the dry bulb temperature are summarized here. Like the calm winds, individual occurrences of these two 'violations' would be reported in the message file.

4.2 UPPERAIR PATHWAY: EXTRACT AND QA

In this section, the contents of the two report files for NWS upper air data are discussed. The reports were generated using the runstream shown in Figure 2.3. The two files are similar to the files generated when processing NWS hourly surface observations. Rather than show entire files in this section, only those portions of the reports where there are significant differences between the surface and upper air report files will be shown.

```
  13 JOB        I19  SETUP: FOUND "END OF FILE" ON UNIT  5
   0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR SURFACE
   0 JOB        I11   TEST: SUMMARY: NO QA FOR SURFACE
   0 JOB        I12   TEST: SUMMARY: NO MERGE FOR SURFACE
   0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR ONSITE
   0 JOB        I11   TEST: SUMMARY: NO QA FOR ONSITE
   0 JOB        I12   TEST: SUMMARY: NO MERGE FOR ONSITE
   0 UPPERAIR   I30  UAEXT: **** UPPER AIR EXTRACTION ****
  20 UPPERAIR   I39  UAEXT:  20 SOUNDINGS EXTRACTED
6107 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -352
6107 UPPERAIR             : ON  88/03/01/07
6107 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -413
6107 UPPERAIR             : ON  88/03/01/07
6107 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -419
6107 UPPERAIR             : ON  88/03/01/07
6107 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -427
6107 UPPERAIR             : ON  88/03/01/07
6107 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -451
6107 UPPERAIR             : ON  88/03/01/07
   2 UPPERAIR   Q36 HTCALC: DEWP MISSING, LVL  2 ON 88 3 1/19
   2 UPPERAIR   +++       : CANNOT RECOMPUTE HTS. ON 88/ 3/ 1/19
6307 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -359
6307 UPPERAIR             : ON  88/03/03/07
     .                                      .
     .                                      .
7019 UPPERAIR   Q37 INTECK: LB:        -350 UATD:        -407
7019 UPPERAIR             : ON  88/03/10/19
  20 UPPERAIR   I39 UAQASM: EOF AFTER UA REPORT #  20 (NORMAL)
```

Figure 4.3. Partial listing of the message file for NWS upper air data.

The first seven records in the message file are similar to those in Figure 4.1, but indicate that there are no NWS surface and on-site to process. Record 9 indicates that 20 upper air soundings were retrieved. For twice-daily soundings, this is the correct number to retrieve. This record is followed by the QA messages, and there were several violations. The first QA message indicates that subroutine INTECK detected a lower bound violation (indicated by LB:) of the dew point (UATD). Table B-1 contains a list of variable names and the default upper and lower bounds for the upper air QA. The value AERMET checks against is -350 (-35.0 °C multiplied by 10); the actual value in the data is -352 (or -35.2 °C), which occurred on 88/03/01/07 (Julian day

61, hour 7), i.e., the 0700 LST sounding on March 1, 1988. In these messages, there is no indication as to which level was in violation; the user will have to examine the data to determine the level. The next four messages indicate that the dew point was in violation at several levels for this sounding. It is important to note that these reports do not mean there are errors in the data. The messages simply alert the user that the data should be examined. Sound meteorological judgement should be used to determine if the data are in error. The data that generated the messages in Figure 4.3 are most likely valid - the dew points are less than the lower bound but not outside the range of possibility. If the user wants a less strict lower bound, the AUDIT keyword statement can be used to adjust the lower bound to something smaller (see Section 3 for a discussion of the AUDIT keyword).

There is one QA message that differs from the others. Subroutine HTCALC reports that the sounding heights cannot be recomputed for the 1900 LST sounding on March 1 because the dew point is missing at the second level. AERMET will attempt to compute the sounding heights using the hypsometric equation (see Section 5) and report any height that differs by more than 50 meters from the observed height at that level. AERMET does not adjust the heights. If the heights cannot be computed, then a message such as in Figure 4.3 is printed.

Figure 4.4 shows a portion of the summary report. Only the QA portion is shown; the first two "pages" are similar to those shown in Figures 4.2a and 4.2b. The first thing to notice is that the structure is slightly different. The table is divided height intervals because soundings have multiple levels of data and the heights of those levels vary from sounding to sounding. The QA violations are tallied into these intervals. Otherwise, the table is identical in structure to the table in Figure 4.2c. From examining the table, there were several bounds violations of the lapse rate (UALR) within several height intervals and there were 20 lower bound violations of the dew point, all at heights above 3000 meters (above local ground).

1 AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
VERSION 1.10

TODAY'S DATE AND TIME: 16-JUL-95 AT 14:47:10

****
*** JOB TERMINATED NORMALLY ***
****

**** SUMMARY OF THE QA AUDIT ****

SOUNDINGS	TOTAL # OBS	VIOLATION SUMMARY: # MISSING	LOWER BOUND	UPPER BOUND	% ACCEPTED	TEST VALUES: MISSING FLAG	LOWER BOUND	UPPER BOUND
SURFACE								
UATT	19	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	19	0	0	0	100.00	-9990.0,	-350.0,	350.0
0 - 500M								
UATT	65	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	65	0	0	0	100.00	-9990.0,	-350.0,	350.0
UALR	65	0	1	2	95.38	-9999.0,	-2.0,	5.0
500 - 1000M								
UATT	46	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	46	0	0	0	100.00	-9990.0,	-350.0,	350.0
UALR	46	0	0	0	100.00	-9999.0,	-2.0,	5.0
1000 - 1500M								
UATT	43	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	43	0	0	0	100.00	-9990.0,	-350.0,	350.0
UALR	43	0	1	0	97.67	-9999.0,	-2.0,	5.0
1500 - 2000M								
UATT	49	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	49	0	0	0	100.00	-9990.0,	-350.0,	350.0
UALR	49	0	0	1	97.96	-9999.0,	-2.0,	5.0
2000 - 2500M								
UATT	50	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	50	0	0	0	100.00	-9990.0,	-350.0,	350.0
UALR	50	0	0	0	100.00	-9999.0,	-2.0,	5.0
2500 - 3000M								
UATT	31	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	31	0	0	0	100.00	-9990.0,	-350.0,	350.0
UALR	31	0	0	0	100.00	-9999.0,	-2.0,	5.0
3000 - 3500M								
UATT	29	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	29	0	1	0	96.55	-9990.0,	-350.0,	350.0
UALR	29	0	0	0	100.00	-9999.0,	-2.0,	5.0
3500 - 4000M								
UATT	20	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	20	0	6	0	70.00	-9990.0,	-350.0,	350.0
UALR	20	0	0	0	100.00	-9999.0,	-2.0,	5.0
> 4000M								
UATT	56	0	0	0	100.00	-9990.0,	-350.0,	350.0
UATD	56	0	13	0	76.79	-9990.0,	-350.0,	350.0
UALR	56	0	0	0	100.00	-9999.0,	-2.0,	5.0

NOTE: TEST VALUES MATCH INTERNAL SCALING APPLIED TO VARIABLES
(SEE APPENDIX B OF THE USER'S GUIDE)

THE FOLLOWING CHECKS WERE ALSO PERFORMED FOR THE UPPER AIR QA
OF 20 REPORTS, THERE WERE
0 CALM WIND CONDITIONS (WS=0, WD=0)

Figure 4.4. Tabular results of the QA of NWS upper air data.

4.3 ONSITE PATHWAY: QA

In this section, the contents of the two report files for quality assessment of on-site data are discussed. Recall that there is no data extraction for on-site data because, unlike NWS data, the data are not stored in an archive format. The reports were generated using the runstream shown in Figure 2.5. Rather than show entire files in this section, only portions of the output reports where there are significant differences between the reports for NWS data and on-site data are shown.

```
  36 JOB      I19  SETUP: FOUND "END OF FILE" ON UNIT  5
   0 JOB      I10   TEST: SUMMARY: NO EXTRACT FOR UPPERAIR
   0 JOB      I11   TEST: SUMMARY: NO QA FOR UPPERAIR
   0 JOB      I12   TEST: SUMMARY: NO MERGE FOR UPPERAIR
   0 JOB      I10   TEST: SUMMARY: NO EXTRACT FOR SURFACE
   0 JOB      I11   TEST: SUMMARY: NO QA FOR SURFACE
   0 JOB      I12   TEST: SUMMARY: NO MERGE FOR SURFACE
6111 ONSITE   Q59 OSQACK: TT   MISSING ON 88/03/01/11, LEVEL: 1
6111 ONSITE   Q59 OSQACK: TT   MISSING ON 88/03/01/11, LEVEL: 2
6111 ONSITE   Q59 OSQACK: TT   MISSING ON 88/03/01/11, LEVEL: 3
6111 ONSITE   Q59 OSQACK: WD   MISSING ON 88/03/01/11, LEVEL: 1
6111 ONSITE   Q59 OSQACK: WD   MISSING ON 88/03/01/11, LEVEL: 2
6111 ONSITE   Q59 OSQACK: WD   MISSING ON 88/03/01/11, LEVEL: 3
6111 ONSITE   Q59 OSQACK: WS   MISSING ON 88/03/01/11, LEVEL: 1
6111 ONSITE   Q59 OSQACK: WS   MISSING ON 88/03/01/11, LEVEL: 2
6111 ONSITE   Q59 OSQACK: WS   MISSING ON 88/03/01/11, LEVEL: 3
       .                               .
       .                               .
6810 ONSITE   Q59 OSQACK: WS   MISSING ON 88/03/08/10, LEVEL: 1
6810 ONSITE   Q59 OSQACK: WS   MISSING ON 88/03/08/10, LEVEL: 2
6810 ONSITE   Q59 OSQACK: WS   MISSING ON 88/03/08/10, LEVEL: 3
 960 ONSITE   I59 OSFILL: FOUND EOF FILE
```

Figure 4.5. Partial listing of messages generated from on-site data processing.

The messages generated by processing the on-site data are shown in Figure 4.5. The first seven records in the message file are similar to those in Figure 4.1 and indicate that there are no NWS surface and upper air data to process. Notice that there isn't a record indicating how many observations were extracted because there is no extraction process for on-site data.

There is a new type of message shown here - missing data. On March 1, 1988 at hour 11, the temperature (TT), wind direction (WD) and wind speed (WS) were reported as missing at levels 1, 2 and 3. There were several instances where one or more levels of a variable were missing for the 10 days of data that were processed. The variable names used in this report correspond to those names found in Table B-3.

Although the data in this example are reported hourly, on-site data may include observations within each hour that are averaged to produce one observation for the hour as a whole. (The number of observations that are present each hour is specified on an OBS/HOUR statement; see Section 3 for a discussion of this keyword.) Within-hour violations generate messages that begin with the code 'I', while a violation by the resulting hourly average generates a message beginning with the code 'Q'. This convention is followed so the number of quality assessment messages better reflects the number of hours with violations.

Figures 4.6a - 4.6c shows the corresponding summary report. The first page has been omitted; it is similar to the one shown in Figure 4.2a except that information for on-site data rather than NWS data are reported. The message tabulation is shown in Figure 4.6a. Note that there were 61 quality assessment violations (hence, the reason for not showing all the messages in Figure 4.5). At his point, the summary report deviates from the structure shown in Figures 4.2 and 4.4. The site-specific, direction dependent surface characteristics that AERMET will use to estimate the boundary layer parameters is printed in the summary report (Figure 4.6b). The minimum detectable wind speed that is used for processing calm winds for on-site data is listed first. The "HEIGHTS FOR MULTI-LEVEL DATA" are all zero because there was no HEIGHTS keyword statement in the runstream. The albedo, Bowen ratio, and surface roughness are shown by month and sector where month 1 = January. There was only one wind direction sector specified - the entire compass (0° - 360°). These values reflect the parameters entered on the FREQ_SECT, SECTOR and CHARS keyword statements shown in Figure 2.5. The final figure in this sequence, Figure 4.6c, shows the more traditional tabular summary of the quality assessment. The % ACCEPTED reports the percentage of observations that are nonmissing or did not violate a bound. The summary is reported by data level and the variables shown are audited by default.

1 AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
VERSION 1.10

TODAY'S DATE AND TIME: 16-JUL-95 AT 14:48:25
INITIAL PROCESSING ON RAW METEOROLOGICAL DATA

```
******************************************************
***              JOB TERMINATED NORMALLY           ***
******************************************************
```

**** AERMET MESSAGE SUMMARY TABLE ****

		0- 9	10-19	20-29	30-39	40-49	50-59	60-69	70-89	TOTAL
JOB	E	0	0	0	0	0	0	0	0	0
	W	0	0	0	0	0	0	0	0	0
	I	0	7	0	0	0	0	0	0	7
ONSITE	E	0	0	0	0	0	0	0	0	0
	W	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	0	1	0	0	1
	Q	0	0	0	0	0	61	0	0	61
		0	7	0	0	0	62	0	0	69

**** WARNING MESSAGES ****

--- NONE ---

**** ERROR MESSAGES ****

--- NONE ---

Figure 4.6a. Summary file for the on-site data quality assessment.

```
1        AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                    VERSION 1.10

                     TODAY'S DATE AND TIME: 16-JUL-95 AT 14:48:26

              THE FOLLOWING ON-SITE VALUES ARE IN EFFECT


   MINIMUM DETECTABLE WIND SPEED (M/S):        1.00000


   HEIGHTS FOR MULTI-LEVEL DATA (M):

     0.00     0.00     0.00


   SURFACE CHARACTERISTICS, MONTHLY BY WIND SECTOR

              WIND                BOWEN      ROUGHNESS
      MONTH  SECTOR   ALBEDO      RATIO       LENGTH
        1       1    0.35000    0.80000     0.30000

        2       1    0.35000    0.80000     0.30000

        3       1    0.35000    0.80000     0.30000

        4       1    0.25000    0.40000     0.50000

        5       1    0.25000    0.40000     0.50000

        6       1    0.12000    0.20000     0.70000

        7       1    0.12000    0.20000     0.70000

        8       1    0.12000    0.20000     0.70000

        9       1    0.20000    0.60000     0.50000

       10       1    0.20000    0.60000     0.50000

       11       1    0.20000    0.60000     0.50000

       12       1    0.35000    0.80000     0.30000


            WIND SECTOR DEFINITIONS:
      INDEX     AZIMUTH: START        END
        1                 0.00     360.00
```

Figure 4.6b. Continuation of the on-site data summary report.

1 AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
VERSION 1.10

TODAY'S DATE AND TIME: 16-JUL-95 AT 14:48:26

****
*** JOB TERMINATED NORMALLY ***
****

**** SUMMARY OF THE QA AUDIT ****
THERE IS NO AUDIT TRAIL FOR SITE SCALARS

SITE VECTORS	|------VIOLATION	SUMMARY------|				|-----TEST	VALUES-----|	
	TOTAL # OBS	# MISSING	LOWER BOUND	UPPER BOUND	% ACCEPTED	MISSING FLAG	LOWER BOUND	UPPER BOUND
10.00 M								
TT	240	2	0	0	99.17	99.0,	-30.0,	35.0
WD	240	4	0	0	98.33	999.0,	0.0,	360.0
WS	240	4	0	0	98.33	999.0,	0.0,	50.0
50.00 M								
TT	240	41	0	0	82.92	99.0,	-30.0,	35.0
WD	240	2	0	0	99.17	999.0,	0.0,	360.0
WS	240	2	0	0	99.17	999.0,	0.0,	50.0
100.00 M								
TT	240	2	0	0	99.17	99.0,	-30.0,	35.0
WD	240	2	0	0	99.17	999.0,	0.0,	360.0
WS	240	2	0	0	99.17	999.0,	0.0,	50.0

THIS CONCLUDES THE AUDIT TRAIL

Figure 4.6c. Continuation of the on-site data summary report.

4.4 MERGING DATA

In this section, the reports that are generated from merging the three types of data are presented. The reports were generated using the runstream shown in Figure 2.7. The only statement that is new in the message file is the last record indicating that a total of 57 records were processed from the three input files. Note that the message is not in the standard format.

Portions of the summary report are shown in Figures 4.8a and 4.8b. Figure 4.8a is similar to Figure 4.2a, except that there is an entry for each data type plus an entry for the output file on the MERGE pathway. As before, this "page" identifies the file names and station information of the data being processed. Additional information, unique to merged data, is shown in Figure 4.8b. The start and end date for the merged data are reported. Recall that the data for March 1 - 10 were extracted and QA'd for the surface, upper air and on-site data; the file of merged data contains a subset of these data. For each day of merged data, the number of NWS soundings, NWS hourly surface observations and on-site observations that comprise the 24-hour period of data is reported. This information is followed by the total number of observations that were read to create the merged output data. If, for example, the last four days of the 10-day period were merged rather than the first four days, then these values would be 20, 240 and 240. The tabular summary of the messages generated by Stage 2 are also shown in Figure 4.8b. There is no subsection for the MERGE pathway because there were no messages generated directly from the MERGE pathway (the message about the header records is not associated with any pathway). The final "page" of the summary report, which is not shown here, reiterates the on-site surface characteristics and is identical to Figure 4.6b.

```
17 JOB        I19  SETUP: FOUND "END OF FILE" ON UNIT  5
 0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR UPPERAIR
 0 JOB        I11   TEST: SUMMARY: NO QA FOR UPPERAIR
 0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR SURFACE
 0 JOB        I11   TEST: SUMMARY: NO QA FOR SURFACE
 0 JOB        I10   TEST: SUMMARY: NO EXTRACT FOR ONSITE
 0 JOB        I11   TEST: SUMMARY: NO QA FOR ONSITE
     57 HEADERS PROCESSED FROM INPUT FILES
```

Figure 4.7. Message file from merging the three data types.

```
1        AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                    TODAY'S DATE AND TIME: 16-JUL-95 AT 14:49:37
                    INITIAL PROCESSING ON RAW METEOROLOGICAL DATA


                   STATUS REPORT PRIOR TO BEGINNING PROCESSOR RUN


  1.  REPORT FILE NAMES

       ERROR MESSAGES: MERGE.ERR
       SUMMARY OF RUN: MERGE.RPT


  2.  UPPER AIR DATA

       SITE ID    LATITUDE(DEG.)   LONGITUDE(DEG.)   CONVERSION TO LST
      00014735       42.75N            73.80W               5

       THE PROCESS(ES) AERMET ANTICIPATES TO PERFORM ARE
        MERGE ONLY

       QA OUTPUT      -     OPEN: UPAIRQA.DSK


  3.  NWS SURFACE DATA

       SITE ID    LATITUDE(DEG.)   LONGITUDE(DEG.)   CONVERSION TO LST
         14735       42.75N            73.80W               0

       THE PROCESS(ES) AERMET ANTICIPATES TO PERFORM ARE
        MERGE ONLY

       QA OUTPUT      -     OPEN: SFCQA.DSK


  4.  ON-SITE DATA

       SITE ID    LATITUDE(DEG.)   LONGITUDE(DEG.)   CONVERSION TO LST
        LOVETT        41.3N             74.0W               0

       THE PROCESS(ES) AERMET ANTICIPATES TO PERFORM ARE
        MERGE ONLY

       QA OUTPUT      -     OPEN: LVTOQA.MET
```

Figure 4.8a. Summary report from merging the three data types.

```
1       AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                     TODAY'S DATE AND TIME: 16-JUL-95 AT 14:49:37

                     ***** USER INPUT PARAMETERS FOR MERGE *****

                        MERGED DATA BEGIN (YR/MO/DA) 88/ 3/ 1
                                AND END              88/ 3/ 4

                     ***** DAILY OUTPUT STATISTICS *****
                  MO/DA  3/ 1  3/ 2  3/ 3  3/ 4
  NWS  UPPER AIR  SDGS   3     4     4     4
  NWS SFC OBSERVATIONS  24    24    24    24
  ON-SITE OBSERVATIONS  24    24    24    24

      UPPER AIR OBS. READ:     9
      SURFACE OBS. READ:      98
      ON-SITE OBS. READ:      97

                     ***** MERGE PROCESS COMPLETED *****

1       AERMET, A METEOROLOGICAL PROCESSOR FOR THE AERMOD DISPERSION MODEL
                                  VERSION 1.10

                     TODAY'S DATE AND TIME: 16-JUL-95 AT 14:49:38
                     INITIAL PROCESSING ON RAW METEOROLOGICAL DATA

                 ********************************************************
                 ***             JOB TERMINATED NORMALLY              ***
                 ********************************************************

                        **** AERMET MESSAGE SUMMARY TABLE ****

               0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89
  TOTAL

  ----------------------------------------------------------------------

     JOB
        E      0       0       0       0       0       0       0       0
  0
        W      0       0       0       0       0       0       0       0
  0
        I      0       7       0       0       0       0       0       0
  7
```

Figure 4.8b. Continuation of the summary report from merging the three data types.

SECTION 5

TECHNICAL NOTES

This section provides a technical description of the processing methods employed by AERMET. This includes quality assessment procedures beyond the simple check against upper and lower bounds, the averaging method used to produce hourly values when on-site data contains more than one observation period each hour, and modifications that can be made to NWS upper air data. The section concludes with a discussion of the estimates of the boundary layer parameters written to the OUTPUT file.

5.1 QUALITY ASSURANCE PROCEDURES

The main quality assessment procedures are similar for all types of data. Each variable is checked to see if it is missing (its value matches the missing code), and if not missing, the value is checked to see if it is within the acceptable bounds. Appendix B lists the variables for each type of data, their units, default acceptance ranges and missing value codes. Note that a violation does not necessarily indicate an error in the data. For example, it could mean the bounds are not reasonable for a particular time of year. It is up to the user to determine if the reported violations are data errors or not.

For NWS hourly surface observations, several additional checks between variables are also performed. NWS surface data are checked for dew-point temperature exceeding dry-bulb temperature (DPTP > TMPD), and having a zero wind speed (WIND = 0), indicating calm conditions, but a non-zero wind direction (WD16), indicating non-calm conditions, or vice versa. The number of occurrences of calm wind conditions are also noted.

AERMET estimates the heights reported in the sounding using the hypsometric equation

$$Z_2 = Z_1 + [(R_d * T_v)/g] * \ln(p_1/p_2)$$

where Z_1 and p_1 are the height and pressure at the lower level, Z_2 and p_2 are the height and pressure at the upper level, R_d is the dry gas constant, T_v is the mean virtual temperature through the layer, and g is the gravitational acceleration. The recomputed height is compared to the reported height. If the difference exceeds 50 meters, then a message is written to the message file (defined on the ERRORS keyword statement). If the surface height is missing, then this check is skipped.

NWS upper air sounding data contain data for multiple levels, so AERMET will examine the *gradient* of some variables within the sounding. AERMET checks four different, between-level gradients. The first is the gradient of the temperature, or *lapse rate* (UALR). The units for this gradient are expressed as an integer number of °C/100 meters. The default range for lapse rate is −2 to +5 °C/100 meters.

The (vertical) gradient of the wind velocity, the wind *shear*, is a vector quantity, composed of two components, *speed shear* (UASS) and *direction shear* (UADS). The wind speed shear is computed as the absolute difference in the speeds between adjacent levels, in ms^{-1}/100 meters. Since it is an absolute difference, it is always non-negative. The default range for the speed shear is 0 to +5 ms^{-1}/100 meters. The wind direction shear is also an absolute difference, expressed in degrees/100 meters. The default range is 0 to 90.0 degrees/100 meters.

The vertical gradient of the dew-point temperature, unlike the other gradients, is computed using <u>three</u> consecutive levels. An estimate of the dew-point at each intermediate height is found using linear interpolation between the dew-points for the adjacent upper and lower heights. The absolute difference between the estimate and the observed dew-point temperature at this intermediate level is divided by the difference between the upper and lower heights. This defines the gradient of the dew-point (UADD) in °C/100 meters. The default range is 0 to +2 °C/100 meters.

The QA on the gradients are summarized with the QA of the observed sounding data. Because there may be a variable number of levels in a sounding, and the heights of the levels may differ from sounding to sounding, the results are accumulated into ten height categories. These are defined as surface, every 500 meters up to 4000 meters, and above 4000 meters. Thus the categories are: surface, 0 - 500, 500 - 1000, ..., 3500 - 4000, and 4000+, where each intermediate category includes the upper but not the lower height. (The "thickness" of the categories is controlled by the internal common variable UAINC. This is specified in a DATA statement in MASTER.INC, and cannot be changed without also recompiling and relinking AERMET.

Lapse rate and shear violations are tallied in the category containing the upper height, while those of the dew-point gradient are tallied in the height category of the middle (intermediate) point. In the absence of missing data and with N levels in a sounding, there should be $N-1$ lapse rate and shear calculations, and $N-2$ dew-point gradient calculations. All range violations and instances of missing values are reported in the ERRORS file and summarized in the general report.

5.2 ON-SITE DATA - AVERAGING SUBHOURLY VALUES

The on-site DATA file may contain several observations during each hour. The number of observations per hour is specified on the optional OBS/HOUR statement when there are more than one observation each hour. See Section 3.5.13 for a discussion on how to use this keyword. The on-site meteorological guidance document (EPA, 1987) suggests at least half of this number must be present to calculate an average for the hour. AERMET follows this guidance and computes an average only when half or more of the subhourly values are not missing.

For most variables the hourly value is computed as the arithmetic mean. However, the wind speed and the wind direction are treated differently to properly differentiate between cases when values are missing and cases when values are present but below the instrument's threshold. This threshold is 1.0 m/s by default, but can be set lower (but not higher) through the MIN_WIND keyword statement (Section 3.5.12). Wind speeds less than threshold are given a value of one-half the threshold wind speed and the wind direction is set to missing. The hourly wind speed is then computed as an arithmetic mean, while the hourly wind direction is computed according to the method given in Section 6.1 of the on-site meteorological guidance document (EPA, 1987) to properly account for the 0-360 degree crossover.

The hourly value for all standard deviations of wind fluctuations (both speed and direction) are computed as the root-mean-square of the subhourly values as per the on-site guidance document (EPA, 1987).

5.3 UPPER AIR DATA MODIFICATIONS

During the extraction of upper air soundings from the raw input DATA file, AERMET can check for possible errors and reduce the impact of strong gradients in each sounding. If the MODIFY keyword statement (Section 3.4.10) is included, the following modifications are performed:

- A mandatory level within 1 percent (with respect to pressure) of a significant level is deleted;
- For a non-zero wind direction with a corresponding zero wind speed, the wind direction is replaced with zero;
- Missing values of dry bulb and dew-point temperature are replaced by an interpolated value if the data for the levels immediately above and below are not missing;

There is no way to turn on individual actions. Either all the actions are performed or none of them are performed. Warning messages are written if the data are modified. These include the date and time in the format YYMMDD/HH, where YY = year, MM = month, DD = day and HH = hour (1-24).

5.3.1 Mandatory Levels

If a mandatory sounding level is within one percent of a significant level (with respect to pressure) then the mandatory level is deleted, with little of information about the structure of the atmosphere. If the maximum number of levels of data were extracted (currently set at 30 and is defined in the variable UAML in UA1.INC), then a sounding may have fewer than the maximum number of levels because the deletion process takes place after the data in a sounding are extracted from the archived data file. AERMET does not attempt to read more levels after deleting a level.

5.3.2 Calm Wind Conditions

The wind speed and wind direction at each level are checked to insure that there are no levels with a zero wind speed and a non-zero wind direction. If one is found, the wind direction is set to zero to represent calm conditions.

5.3.3 Missing Dry Bulb and Dew-Point Temperatures

If the dry-bulb or dew-point temperature is missing at some level, then an estimate for the missing temperature is made by linearly interpolating to the level in question. The data from the level immediately below and above the level in question are used. If the data that are required for the interpolation are also missing, then no interpolation is performed.

5.4 BOUNDARY LAYER PARAMETER ESTIMATES IN STAGE 3

AERMOD uses several different boundary layer parameters to model how pollutants disperse in the atmosphere. Many of these parameters are not observed, but are estimated from other variables that are more easily measured. To make these estimates, surface characteristics at the surface are required. These characteristics are discussed in detail in Sections 2 and 3, but because of the importance in estimating boundary layer parameters, they are briefly reviewed here.

5.4.1 Surface Characteristics

The atmospheric boundary layer is that region between the earth's surface and the overlying, free flowing (geostrophic) atmosphere. The fluxes of heat and momentum drive the growth and structure of this boundary layer. The depth of this layer, and the dispersion of pollutants within it, are influenced on a local scale by surface characteristics, such as the roughness of the underlying surface, the reflectivity of the surface (or albedo), and the amount of moisture available at the surface. From these input parameters and observed atmospheric variables, AERMET calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity u_*, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux H, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length L, a stability parameter relating u_* and H; the daytime mixed layer height z_i and the nocturnal surface layer height h; and w_*, the convective velocity scale that combines z_i and H. These parameters all depend on the characteristics of the underlying surface.

Although very general default values exist in AERMET, the user should specify the albedo (r), which is the fraction of radiation reflected by the surface; the daytime Bowen ratio, B_o, which is the ratio of the sensible heat flux H to the heat flux used in evaporation λE; and the surface roughness length z_o, which is the height above the ground at which horizontal wind velocity is typically zero. These measures depend on land-use type (e.g., urban area, deciduous/coniferous forest, cultivated land, calm waters) and vary with the seasons (See Tables 3.1 - 3.3) and wind direction.

The user specifies these values on CHARS keyword statements for one, four or 12 (ANNUAL, SEASONAL, or MONTHLY) time periods per year, and 1 - 12 nonoverlapping, contiguous wind direction sectors that cover the full 360°. The user is referred to Section 2.2.2.4 and Section 3.5.9 for a more detailed discussion on specifying these parameters for AERMET.

5.4.1.1 Choice of Sector-Dependent Surface Characteristics

In defining sectors for surface characteristics, Irwin (1994) suggests that a user specify a sector no smaller than a 30-degree arc. The expected wind direction variability over the course of an hour, as well as the encroachment of characteristics from the adjacent sectors with travel time, make it hard to preserve the identity of a very narrow sector's characteristics. However, using a weighted average of characteristics by surface area within a 30-degree sector makes it possible to have a unique portion of the surface significantly influence the properties of the sector that it occupies.

The length of the upwind fetch for defining the nature of the turbulent characteristics of the atmosphere at the source location has been defined as 3 kilometers in EPA's Guideline on Air Quality Models (Revised)(EPA, 1993). This specification results from a paper by Irwin (1978), which also cites a study by Högström and Högström (1978). The basic premise is that when the wind blows over an area with a change in its surface characteristics, a new "boundary layer" with the turbulent characteristics of the underlying surface develops and deepens along the wind direction. Högström and Högström present tabular results for the boundary layer growth as a function of roughness length in rural areas. Irwin (1978) noted that the region of enhanced turbulence with a depth of 400 meters was reported by Shea and Auer (1978) for St. Louis, and curves based on the Högström and Högström data indicate that a 3-km fetch would attain this boundary layer height. The resulting 3-km fetch was made a part of the recommended urban/rural land-use procedure in the EPA's modeling guideline, and was also adopted by METPRO (Paine, 1987), the CTDMPLUS meteorological pre-processor for its definition of sector-specific surface characteristics.

For a surface with a large roughness, however, the rate of the boundary layer growth as defined by Högström and Högström (1978) could be sufficiently rapid so as to grow to a depth of 400 meters within 1 kilometer downwind. In the case of a lower boundary layer depth, such as 100 meters, the Högströms calculate that the distance needed to attain an urban-influenced boundary height of just 100 meters with a surface roughness ranging from 0.5 to 1.5 meters is only about 250 meters for unstable (convective) conditions, 700 meters for neutral conditions, and 1330 meters for slightly stable conditions.

For AERMET applications, an upwind fetch distance of 3 kilometers is recommended for defining user-specified values such as albedo, Bowen ratio, and surface roughness. In each sector, it is likely that a mixture of land use is present, and the resulting user input should be a weighted average of the values selected for each land use type. For urban areas or areas with a very large roughness length, consideration can be given for a smaller upwind fetch distance for defining the user-specified surface characteristics. The actual fetch length selected would be a function of the expected plume height, the roughness length, and any urban heat flux that would tend to minimize the presence of stable conditions in the surface layer. Högström and Högström (1978) can be used as guidance in these cases.

5.4.2 Estimates for the Unstable Atmosphere

As defined in AERMET, the atmosphere is unstable if the flux of sensible heat is upward at the surface, and the time of day is approximately between sunrise and sunset. During daytime convective conditions, the surface of the earth is heated, resulting in an upward transport of heat. Hourly estimates of this heat flux are required to estimate the daytime mixed layer height. The estimates here follow the development of Holtslag and van Ulden (1983). Beginning with the surface energy balance, H is determined hour-by-hour from the net radiation and Bowen ratio. AERMET first looks for net radiation (from the on-site data) and uses it if found. If there is no net radiation, then AERMET looks for solar radiation (again from the on-site data) and uses it and opaque cloud cover (from the NWS) to estimate net radiation. If there is no solar radiation, then it is estimated as described below from cloud cover and surface temperature (using on-site observations if available, NWS data if not), Bowen ratio, and albedo. Once the heat flux is computed, u_* and L are determined through an iterative procedure using surface layer similarity. While u_* and L change with each iteration, the hourly heat flux remains fixed.

A simple equation that expresses the energy balance at the earth's surface is:

$$R_N = H + \lambda E + G \qquad (5.1)$$

where R_N is the net radiation, λE is the latent heat flux, and G is the flux of heat into the ground. Following Holtslag and van Ulden (1983), $G = 0.1\,R_N$. Using this estimate for G and the Bowen ratio ($B_o = H/\lambda E$) yields the following expression for H:

$$H = 0.9 R_N \,/\, (1 + (1 \,/\, B_o)) \qquad (5.2)$$

Net radiation R_N can either be an observed quantity from on-site data (variable NRAD), or it can be estimated from the total incoming solar radiation, R, as follows:

$$R_N = (1 - r)R - I_N \qquad (5.3)$$

where r is the surface albedo, and I_N is the net long-wave radiation at the earth's surface.

In the general case in which clouds are present, R is computed using the following estimate from Kasten and Czeplak (1980)

$$R = R_0 (1 + b_1 N^{b_2}) \qquad (5.4)$$

where R_0 is the incoming solar radiation at ground level for clear skies, and N is the fractional opaque cloud cover (variable TSKC). The empirical coefficients b_1 and b_2 are assigned the values of -0.75 and 3.4, respectively (from Holtslag and van Ulden, 1983). If cloud cover and observed net radiation are missing for a particular hour, no further calculations can be made for that hour. A warning message is written in this case.

The incoming solar radiation for clear skies R_0 is given by

$$R_0 = a_1 \sin\phi + a_2 \tag{5.5}$$

where ϕ is the elevation of the sun above the horizon, $a_1 = 990$ W m^{-2} and $a_2 = 30$ W m^{-2}. The constants a_1 and a_2 account for attenuation of the short wave radiation by water vapor and dust in the atmosphere. The values used by AERMET are appropriate for mid-latitudes (Holtslag and van Ulden (1983)).

Substituting Eqs. 5.4 and 5.5 into 5.3 and parameterizing the net long-wave radiation as a function of temperature and cloud cover, Holtslag and van Ulden (1983) estimate the net radiation as:

$$R_N = \frac{(1 - r)R + c_1 T^6 - \sigma_{SB} T^4 + c_2 N}{1 + c_3} \tag{5.6}$$

where $\sigma_{SB} = 5.67 \times 10^{-8}$ W m^{-2} K^{-4} is the Stefan-Boltzmann constant, and the other empirical constants are as follows: $c_1 = 5.31 \times 10^{-13}$ W m^{-2} K^{-6}, $c_2 = 60$ W m^{-2}, $c_3 = 0.12$

The surface albedo r supplied by the user should be for solar elevation angles above 30°, for which r is relatively constant. However, r increases for lower angles (Coulson and Reynolds (1971) and Iqbal (1983)). An empirical expression for the albedo as a function of solar elevation angle is given by

$$r = r' + (1 - r')e^{a\nu + b} \tag{5.7}$$

(Paine, 1987) where r' is the albedo for the sun directly overhead, ν is the solar elevation angle in degrees, $a = -0.1$, and $b = -0.5\,(1 - r')^2$.

With an estimate of the heat flux, AERMET next estimates the surface friction velocity u_* and the Monin-Obukhov length L for the convective boundary layer (CBL) through an iterative procedure. (This technique used is similar to that used in the METPRO meteorological preprocessor (Paine (1987).) The two equations for u_* and L used in the iteration algorithm are:

$$u_* = \frac{k\,U}{\ln(\frac{z_{ref}}{z_o} - \Psi + \Psi_o)} \tag{5.8}$$

and

$$L = -\frac{\rho\, c_p\, T\, u_*^3}{k\, g\, H} \tag{5.9}$$

where

k is the von Karman constant (0.4),

U is the reference height wind speed (m s^{-1}),

z_{ref} is the reference height (about 7 meters for NWS data),

z_o is the surface roughness length (m),

ρ is the density of dry air (kg m^{-3}),

c_p is the specific heat capacity of air (J kg^{-1} deg^{-1}),

T is ambient temperature (K), and

g is the acceleration due to gravity (m s^{-2}).

The reference height z_{ref} for on-site data is taken as the first height above $20*z_o$ and below 100 meters. The values of Ψ and Ψ_0 are given by:

$$\frac{1+\mu}{2}) + \ln(\frac{1+\mu^2}{2}) - 2\tan^{-1} \qquad (5.10)$$

$$\frac{1+\mu_o}{2}) + \ln(\frac{1+\mu_o^2}{2}) - 2\tan^{-1} \qquad (5.11)$$

and

$$\mu = (1 - 16 z_{ref} / L)^{1/4} \qquad (5.12)$$

$$\mu_o = (1 - 16 z_o / L)^{1/4} \qquad (5.13)$$

This procedure requires an initial guess for u_*, which is found by initially setting Ψ and Ψ_o to zero. The iteration continues until consecutive values of L differ by 1% or less.

The convective boundary layer height is based on the formulation by Carson (1973) and modified by Weil and Brower (1983). The Carson model is based on a one-dimensional (height) energy balance approach, in which the heat flux in the CBL at the surface, and entrained from the stable air aloft, leads to vertical mixing, a rise in the base of the elevated temperature inversion, and an increase of the energy of the boundary layer air. The original Carson model is based on an initial (early morning) potential temperature profile that is assumed to be linear with height. Weil and Brower (1983) extended Carson's model to an arbitrary initial temperature distribution with z (height) and allowed for stress-induced (mechanical) mixing at top of the PBL. The latter can be important when H is small, e.g., in the early morning or on overcast days. In this version of AERMET, the mechanical mixing is ignored. An operational advantage of the arbitrary temperature distribution is the ease of adapting it to initial profiles that are very irregular, as is sometimes found in early morning rawinsondes.

Weil and Brower find z_i implicitly from the following equation:

$$-\int_0^{z_i} \theta(\nu)\, d\nu = (1 + 2A)\int_0^{t} - \qquad (5.14)$$

where $\theta(z)$ is the initial potential temperature distribution (from the 12Z sounding), and the right-hand-side represents the cumulative heat flux input at $z = 0$.

Once z_i is found, the turbulent velocity scale w_* can be found from the following definition:

$$w_* = (\, gHz_i \,/\, \rho c_p T \,)^{1/3}. \qquad (5.15)$$

5.4.3 Estimates for the Stable Atmosphere

The stable boundary layer (SBL) calculations, based on an approach outlined by Venkatram (1980), are straight-forward and do not require an iterative process as is used in the CBL calculations. Estimates of u_* and θ_*, a temperature scale, are made from cloud cover, wind speed and temperature, which, in turn, provides an estimate of the heat flux. The Monin-Obukhov length then is computed directly from Eq. 5.9.

The method begins with the following estimate for the temperature scale θ_*:

$$\theta_* = 0.09(1 - 0.5N^2) \tag{5.16}$$

where N is the fractional opaque cloud cover. Two quantities, the neutral drag coefficient C_D and u_o, are calculated as:

$$C_D = \frac{k}{\ln(z_{ref}) / z_o)} \tag{5.17}$$

and

$$u_o = (\beta_m z_{ref} g \theta_* / T)^{1/2} . \tag{5.18}$$

Using $H_0 = -\rho c_p u_* \theta_*$ in Eq. 5.9 and

$$k\frac{u}{u_*} = \ln\left(\frac{z_{ref}}{z_0}\right) + \beta_m \frac{z_{ref}}{L}$$

the following expression for u_* can be derived:

$$U/2 \ (1 + (1 - (2u_o / C_D U \tag{5.19}$$

To obtain real-valued solutions for u_*, the following condition must be true:

$$4u_o^2 / (C_D^2 U^2) \leq 1 \tag{5.20}$$

If this condition does not hold (under very stable conditions), then the solution to the quadratic equation is imaginary. Equality in the above condition corresponds to a minimum (critical) wind speed, u_{cr}. For wind speeds equal to or greater than u_{cr}, a real-valued solution to Eq. 5.19 is obtained. The critical wind speed is given by

$$u_{cr} = (4 \beta_m z_{ref} g \theta_* / (T C_D))^{1/2} \tag{5.21}$$

For this value, there is a corresponding friction velocity, u_{*cr}, such that

$$u_{*cr} = C_D u_{cr} / 2 \tag{5.22}$$

For wind speeds less than this critical value, Eq. 5.19 no longer yields a real-valued solution, and it is desirable to have $u_* \rightarrow 0$ as $U \rightarrow 0$. Therefore, for $U < u_{cr}$, u_{*cr} is scaled by the ratio U / u_{cr}, and u_* is calculated as

$$u_* = u_{*cr} \frac{U}{u_{cr}} \tag{5.23}$$

For $U < u_{cr}$, van Ulden and Holtslag (1985) showed that there is a nearly linear variation of θ_* with u_*. Therefore, θ_* is similarly scaled as

$$\theta_* = \theta_{*cr} \frac{u_*}{u_{*cr}} \tag{5.24}$$

where θ_{*cr} is given by 5.16.

With the u_* from Eq. 5.19 or 5.23 and the θ_* from Eq. 5.16 or 5.24, the heat flux for the stable atmosphere is computed from

$$H = -\rho c_p u_* \theta_* \tag{5.25}$$

Finally, using these estimates of u_* and H, L is computed from Eq. 5.9.

In the case of strong winds, H may become unrealistically large. Therefore, a limit of -64 W m^{-2} is placed on the heat flux, which forces a limit on the product $u_* \theta_*$. This yields a cubic equation in u_*, which is solved to obtain a new u_*. With this value for u_* and H = -64 W m^{-2}, L is recomputed from Eqs. 5.9 and 5.25.

The SBL height is found from the diagnostic expression given by Nieuwstadt (1984):

$$h/L = \frac{0.3\, u_* / Lf}{1 + 1.9 h/L} \qquad (5.26)$$

which interpolates between a neutral PBL height estimate, 0.3 u_* / f (where f is the Coriolis parameter dependent on latitude) and a strongly stable PBL height estimate, 0.4 $(u_* L/f)^{1/2}$ (as $L \rightarrow 0$).

Equation 5.26 is a quadratic equation in h. Solving for h we find:

$$h = \frac{1}{3.8}\left(-L + \sqrt{L^2 + 2.28\, u_*\, L/f}\right) \qquad (5.27)$$

Since w_* is a scaling parameter for convective conditions, it is not computed for the stable atmosphere and a value of -9.0 is written to the output file.

SECTION 6

COMPUTER NOTES

In this section, the discussion turns to the computer aspects of the AERMET preprocessor. Hardware requirements for AERMET, array limitations, and nonstandard Fortran 77 and platform-specific source code in AERMET are presented. If the source code is changed by the user, then the code must be compiled and linked as described in this section.

6.1 HARDWARE

The desktop personal computer has become a very popular platform for applications in air quality modeling. As such, AERMET is designed to be run primarily on IBM-compatible personal computers (PCs) with an 80386, or equivalent, central processor. To run the Lahey-compiled versions, a math coprocessor is required.

The current version of AERMET was developed on an IBM-compatible PC using the Lahey F77L-EM/32™ Fortran compiler (version 5.2). The source code and two executable programs require approximately 2.6 Mb of disk space. The executable code sizes for STAGE1N2 and STAGE3 are 900 Kb and for STAGE3 850 Kb, respectively.

6.2 ARRAY LIMITATIONS

AERMET has been designed to use a static storage allocation approach, where data are stored in arrays. The array limits are controlled by PARAMETER statements in the source code. The variable name, location and default limit for several key parameters are shown in Table 6-1.

The primary data pathways that are affected by these limits are those with multiple levels of data, i.e., the UPPERAIR and ONSITE pathways.

Table 6-1

MAXIMUM DATA STORAGE LIMITS

PARAMETER NAME	PATHWAY	PURPOSE	FILE LOCATION	ARRAY LIMIT
UAMH	UPPERAIR	Maximum number of soundings per day	UA1.INC	24
UAML	UPPERAIR	Maximum number of sounding levels	UA1.INC	30
UAMV	UPPERAIR	Maximum number of variables per sounding level	UA1.INC	6
SFMH	SURFACE	Maximum number of hours per day of surface obs.	SF1.INC	24
OSMH	ONSITE	Maximum number of hours of data per day	OS1.INC	24
OSMRDS	ONSITE	Maximum number of records per observation period	OS1.INC	40
OSML	ONSITE	Maximum number of levels of data per observation period	OS1.INC	20
OSMDAT	ONSITE	Maximum number of variables per record	OS1.INC	20
OSMSEC	ONSITE	Maximum number of wind direction sector to define surface characteristics	OS2.INC	12
OSMFRQ	ONSITE	Maximum number of periods to define surface characteristics	OS2.INC	12

Another important limit is the number of on-site observation periods per hour. Recall from Sections 2 and 3 that there can be multiple observation periods per hour for the on-site meteorological data. The number of periods is defined by the user with the OBS/HOUR keyword statement on the ONSITE pathway. The maximum number of periods that AERMET allows is 12. There is no variable name associated with this value; the source code in OSSETUP1.FOR explicitly imposes this limit. Currently, there is no quick and simple way to modify this limit.

The values listed in Table 6-1 can be changed to meet specific needs of the users, but STAGE1N2 and STAGE3 must be recompiled and relinked as described below for the changes to take effect.

6.3 COMPILING AND LINKING AERMET

This section provides the details of creating executable programs on a personal computer using the Lahey F77L-EM/32 Fortran Compiler. To create the executable for Stages 1 and 2, the following source code files are required:

STAGE1N2.FOR	-	main program for Stages 1 and 2
COMPLETE.FOR	-	checks the runstream to insure sufficient information has been provided to process data
HEADER.FOR	-	process header records in the input files
LIBFILE1.FOR, LIBFILE2.FOR, LIBFILE3.FOR	-	library of routines used by several subprograms
LIBPC.FOR	-	library of PC-specific routines
MERGE.FOR	-	merges the three data types into one file
OSFILE.FOR	-	processes on-site meteorological data
OSSETUP1.FOR, OSSETUP2.FOR	-	processes the ONSITE pathway keyword statements in an input runstream
SETUP1.FOR, SETUP2.FOR, SETUP3.FOR	-	processes input runstream keyword statements
SFFILE.FOR	-	processes NWS hourly surface observations
UAFILE.FOR	-	processes NWS upper air soundings (or equivalently formatted data)

In addition the following files are required. They contain the variable declarations and common blocks.

MAIN1.INC, MAIN2.INC	-	used throughout
OS1.INC, OS2.INC	-	used in processing on-site meteorological data
SF1.INC,SF2.INC	-	used in processing NWS surface observations
UA1.INC,UA2.INC	-	used in processing NWS upper air soundings
WORK1.INC	-	temporary storage variables and arrays

MASTER.INC	-	initialize variables that are in common blocks

To create the executable for Stage 3, the following source code files are required:

STAGE3.FOR	-	main program for Stage 3
COMPLETE.FOR	-	checks the runstream to insure sufficient information has been provided to process data
HEADER.FOR	-	process header records in the input files
LIBFILE1.FOR, LIBFILE2.FOR, LIBFILE3.FOR	-	library of routines used by several subprograms
LIBPC.FOR	-	library of PC-specific routines
MPMET1.FOR,	-	prepares the meteorological data for use by the selected dispersion model
MPMET2.FOR, MPMET3.FOR, MPMET4.FOR		
MPSETUP1.FOR,	-	processes the METPREP pathway keyword statements in an input runstream for STAGE3
MPSETUP2.FOR, MPSETUP3.FOR		
OSSETUP1.FOR,	-	processes the ONSITE pathway keyword statements in an input runstream
OSSETUP2.FOR		
SETUP1.FOR, SETUP2.FOR, SETUP3.FOR	-	processes input runstream keyword statements

In addition the following files are required. They contain the variable declarations and common blocks.

MAIN1.INC, MAIN2.INC	-	used throughout
MP1.INC, MP2.INC	-	used in processing meteorological data in Stage 3
OS1.INC, OS2.INC	-	used in processing on-site meteorological data
SF1.INC,SF2.INC	-	used in processing NWS surface observations
UA1.INC,UA2.INC	-	used in processing NWS upper air soundings
WORK1.INC	-	temporary storage variables and arrays
MASTER.INC	-	initialize variables that are in common blocks

Only the files ending with the .FOR extension need to be compiled. To compile one of these files with the Lahey compiler, the following command line should be used:

d:\yourpath\f77l3 *filename*.FOR /B /I /L /NO /NW

where *d:\yourpath* is the drive and path where the Lahey compiler resides on your hard drive or network and *filename*.FOR is one of the files listed above. The switches after the filename provide the following control:

/B	checks arrays bounds (when the executable program is run);
/I	interface checking between subprograms;
/L	lists line numbers in the event the executable program terminates abnormally;
/NO	turns off listing the options used to compile the file;
/NW	turns off listing warning messages.

The /NW switch turns off all warning messages when a file is compiled. AERMET generates many warning messages as a result of the INCLUDE (.INC) files. If changes to the code are more extensive than the simple changes to array limits, then this switch should be removed to allow all warning messages to be listed to detect possible problems that the compiler deems not fatal, but in fact may cause serious problems when the programs are run.

The file LIBPC.FOR requires the additional switch /D1LAHEY. This switch allows conditional compilation of statements that are specific to the Lahey compiler. (For the convenience to the user, conditional compilation statements are present for the Microsoft Fortran compiler (version 5.1). Check your Fortran reference manuals for the syntax of the compiler switch.)

Once all the Fortran source code files are compiled, they can be linked to create an executable program. To create the executable STAGE1N2.EXE, the following statement is used:

```
386LINK    STAGE1N2,COMPLETE,HEADER,SETUP1,SETUP2,SETUP3,
           OSSETUP1,OSSETUP2,LIBFILE1,LIBFILE2,LIBFILE3,LIBPC,
           SFFILE,UAFILE,OSFILE,MERGE
           -STUB RUNB  -EXE STAGE1N2.EXE  -PACK
```

The switches after the filenames have the following effect:

-STUB RUNB	binds the Lahey/Phar Lap 386|DOS Extender to the (protected-mode) executable;
-EXE STAGE1N2	defines the name of the executable program;
-PACK	performs data compression on the executable file.

The next, and final, step is optional, and simply disables the 386|DOS Extender banner that is shown whenever the executable program is run:

```
CFIG386 STAGE1N2.EXE -nosignon
```

To create the executable STAGE3.EXE, the following statement is used:

```
386LINK     STAGE3,COMPLETE,HEADER,SETUP1,SETUP2,SETUP3,
            OSSETUP1,OSSETUP2,MPSETUP1,MPSETUP2,MPSETUP3,
            LIBFILE1,LIBFILE2,LIBFILE3,LIBPC,
            MPMET1,MPMET2,MPMET3,MPMET4
            -STUB RUNB  -EXE STAGE3.EXE  -PACK
```

The switches after the filenames have the same effect as for STAGE1N2.EXE. As before, the final step is to disable the 386|DOS Extender banner with

```
CFIG386 STAGE3.EXE -nosignon.
```

6.4 FORTRAN-77 STANDARD AND PLATFORM-SPECIFIC SOURCE CODE

The AERMET preprocessor is designed to be used not only on a PC, but on mainframe computers such as the IBM and Digital Equipment Corporation's VAX. For AERMET to be compatible with the different computing platforms, the preprocessor is written almost entirely in ANSI-standard Fortran-77, with a few exceptions as discussed below. This minimizes modifications that the user must make in the source code to create executable programs. While every effort was made to use only standard Fortran commands without any computer-specific features (extensions), a few subroutines were required that do include such extensions. These subroutines are all grouped together into one platform-dependent file.

6.4.1 Fortran-77 Standard

The AERMET preprocessor is written almost entirely in ANSI-standard Fortran-77 (ANSI, 1978) to ensure portability of the computer code to other computing platforms. Two Fortran constructs that do not follow the Fortran 77 standard are the use of the INCLUDE files and DO WHILE .. END DO construct. The INCLUDE files are discussed in the next section. The DO WHILE structure is discussed here.

To facilitate the development of the source code and to improve readability, the DO WHILE ... END DO construct was used in several places to control looping. This extension is fairly commonplace to the Fortran language and has become a standard in Fortran-90, the most recent standard.

For users who need to install AERMET on systems that do not support this extension of the Fortran language, the following suggestion is offered. First, check the version of the compiler being used, since a more recent version may have added support for this extension. The user may need to specify additional compiler switches to implement the extension. Lacking this option, the user can take the following steps to make the code fully compatible with the Fortran-77 standard. The DO WHILE ... END DO structure should be replaced with the IF ... END IF structure. The change would look similar to the following:

```
C       DO WHILE (logical expression)
label   IF (logical expression) THEN
           .

           .
C       END DO
        GO TO label
        END IF
```

where the DO WHILE and END DO have been commented out with the 'C', 'label' is a statement label by the user and must not repeat a label already in use within the subprogram, and 'logical expression' used for the IF statement must be the same expression as used for the DO WHILE statement. While the use of GO TO statements is somewhat unappealing, these statements provide the same functionality of the DO WHILE ... END DO construct.

6.4.2 Platform-Specific Statements

Nearly all subroutines in AERMET contain system-specific, and nonstandard, statements to include other AERMET files that define COMMON blocks of variables. These files all have the .INC extension. The syntax of the required statements vary according to compiler, but are all a form of the nonstandard INCLUDE statement. The syntax for several platforms and compilers is shown below. The assumption is made that the INCLUDE files are in the same subdirectory (or partitioned data set on an IBM) as the main programs and subroutines that use them. It will be necessary to edit all of the source code files in order to use the correct INCLUDE syntax.

VAX FORTRAN: INCLUDE '*filename*'

where *filename* is any valid VAX file specification. For example: `INCLUDE 'MAIN1.INC'`.

IBM VS FORTRAN: INCLUDE (*name*)

where *name* is the member name in the partitioned data set. For example: `INCLUDE (MAIN1)`.

Microsoft FORTRAN, v5.0: INCLUDE '*filename*'

where *filename* is a valid DOS file specification. For example: `INCLUDE 'MAIN1.FOR'`.

If the user's compiler does not support this extension, then the user can perform the following steps to ensure compatibility with the Fortran-77 standard. Using a text editor, locate the first occurrence of the INCLUDE statement. Comment out this statement (using a C in the first column) and "paste" the appropriate include file in the source code. Repeat the process for each occurrence of the INCLUDE statement in the subprogram, and for each subprogram in the AERMET source code. The user can expect a significant increase in the size of each source code file.

Other PC-dependent statements are in subroutines that are grouped into the file LIBPC.FOR. The subroutines in this file and the purpose of each are:

FLOPEN	opens input and output files.
DATER	returns the operating system date and time. For convenience, both a Lahey and Microsoft version are included (see Section 6.3 for more information).

The AERMET preprocessor uses logical unit 5 as the standard input device (console or keyboard) and unit 6 as the standard output device (screen). These are defined in DATA statements as variables DEVIN and DEVIO, respectively, in MASTER.INC. These unit numbers can easily be changed to accommodate other operating system's default values. However, the programs that include MASTER.INC (STAGE1N2.FOR and STAGE3.FOR) will have to be recompiled and the AERMET system relinked.

SECTION 7

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APPENDIX A

FUNCTIONAL KEYWORD/PARAMETER REFERENCE

This appendix provides a functional reference for the keywords and parameters used by the input runstream files for AERMET. The keywords are organized by functional pathway and within each pathway the order of the keywords is alphabetical, excluding the keyword that identifies the start of a block. The pathways used by AERMET are as follows, in the order in which they appear in the tables that follow:

JOB - for specifying overall **JOB** control options;
UPPERAIR - for processing NWS **UPPERAIR** data;
SURFACE - for processing NWS hourly **SURFACE** data;
ONSITE - for processing **ONSITE** meteorological data;
MERGE - to **MERGE** the three data types into one file;
METPREP - for **PREP**aring **MET**eorological data for a dispersion model.

Two types of tables are provided for each pathway. The first table lists all of the keywords for that pathway, identifies each keyword as to its type (either mandatory or optional, either repeatable or non-repeatable, and if it is reprocessed), and provides a brief description of the function of the keyword. The second type of table, which takes up more than one page for several pathways, describes each parameter in detail.

The following conventions are used in these tables. The parameter names are intended to be descriptive of the input variable being represented. Square brackets around a parameter indicate that the parameter is optional for that keyword. The default that is taken when an optional parameter is left blank is explained in the discussion for that parameter.

TABLE A-1

DESCRIPTION OF JOB PATHWAY KEYWORDS

Keyword	Type	Description
JOB	Optional, Nonrepeatable	Start of JOB block. This statement is optional if the statements associated with this block appear first in the input control file.
ERRORS	Mandatory, Nonrepeatable	Identifies the warning/error messages file.
REPORT	Optional, Nonrepeatable	Identifies the general report file.
SYNTAX	Optional, Nonrepeatable	Flag indicating that only the syntax of the input statements should be checked for errors, i.e., no data are processed.

TABLE A-2

DESCRIPTION OF KEYWORD PARAMETERS FOR THE JOB PATHWAY

Keyword	Parameters	
ERRORS	message_filename	
where:	message_filename	The name of the file where all source-code-generated messages are written
REPORT	summary_filename	
where:	summary_filename	The name of the file where AERMET writes a summary of all preprocessor actions for the current run
SYNTAX	<none>	

TABLE A-3

DESCRIPTION OF UPPERAIR KEYWORDS

Keyword	Type	Description
UPPERAIR	Mandatory, Nonrepeatable	Start of UPPERAIR block.
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variables.
CEILING	Optional, Nonrepeatable, Reprocessed	Set cut-off height (in meters above sea level) beyond which upper air data are ignored.
DATA	Mandatory, Nonrepeatable	File name of raw upper air data.
EXTRACT	Mandatory, Nonrepeatable	File name of extracted upper air data.
LOCATION	Mandatory, Nonrepeatable, Reprocessed	Site ID and location information. Required only for extraction processing.
NO_MISSING	Optional, Repeatable	Identify those AUDIT variables on which to not report occurrences of missing values.
MODIFY	Optional, Nonrepeatable, Reprocessed	Flag indicating adjustments should be made to the soundings when extracted. See §5 for a discussion of these adjustments.
QAOUT	Mandatory, Nonrepeatable	File name of quality assessed upper air data.
RANGE	Optional, Repeatable, Reprocessed	Set new range checks and missing values for QA of indicated data variables.
XDATES	Mandatory, Nonrepeatable	Inclusive dates to be used for data extraction. Required only for extraction processing; should be omitted for QA.

TABLE A-4

DESCRIPTION OF KEYWORD PARAMETERS FOR THE UPPERAIR PATHWAY

Keyword	Parameter(s)	
AUDIT	uaname1 ... uanameN	
where:	uaname1 ... ... uanameN	Specifies the variables name(s), as defined in Table C.1 of Appendix C, that are to be tracked during the quality assessment
CEILING	max_height	
where:	max_height	The maximum height to extract upper air data from the archive data file.
DATA	archive_filename file_format factor [type]	
where:	archive_filename	The name of the file (or tape) containing the archive of upper air data
	file_format	Archive file format: **6201FB** or **6201VB**
	factor	Specifies the number of logical records in one physical record; for data on diskette this value is 1
	[type]	Specifies the collating sequence: **ASCII** (default) or **EBCDIC**; required only when AERMET is run on an IBM mainframe computer
EXTRACT	extracted_data_filename	
where:	extracted_data_ filename	Specifies the name of the output file for data extracted from an archive data file

TABLE A-4, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE UPPERAIR PATHWAY

Keyword	Parameter(s)	
LOCATION	site_id lat/long long/lat tadjust	
where:	site_id	Specifies the station identifier for which data are to be extracted
	lat/long	Specifies the station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator or S for sites south of the equator (or W for sites west of Greenwich or E for sites east of Greenwich)
	long/lat	Specifies the station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich or E for sites east of Greenwich (or N for sites north of the equator or S for sites south of the equator)
	tadjust	Specifies the number of time zones west (for a positive value) or east (for a negative value) of Greenwich
NO_MISSING	uaname1 ... uanameN	
where:	uaname1 ... ... uanameN	Specifies the variable name(s), as defined in Appendix C, of the upper air variables that should be tracked and summarized during the quality assessment, but suppresses writing individual messages to the message file (defined by the ERRORS keyword on the JOB pathway)
MODIFY	<none>	
QAOUT	qa_output_filename	
where:	qa_output_ filename	Specifies the name of the output file from the QA

TABLE A-4 (CONT.)

DESCRIPTION OF KEYWORD PARAMETERS FOR THE UPPERAIR PATHWAY

Keyword	Parameter(s)	
RANGE	uaname lower_bound <[=] upper_bound missing_indicator	
where:	uaname	Specifies the variable name, as defined in Table C.1
	lower_bound	Specifies the minimum value of the valid range of values for uaname
	<[=]	Specifies whether to exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA
	upper_bound	Specifies the maximum value of the valid range of values for uaname
	missing_indicator	Specifies the value to use to indicate the value is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
	YB/MB/DB	Specifies the beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make the keyword statement more readable
	YE/ME/DE	Specifies the ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

TABLE A-5

DESCRIPTION OF SURFACE PATHWAY KEYWORDS

Keyword	Type	Description
SURFACE	Mandatory, Nonrepeatable	Start of SURFACE block.
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variable.
DATA	Mandatory, Nonrepeatable	Input file name of raw surface data.
EXTRACT	Mandatory, Nonrepeatable	File identifier of extracted surface data.
LOCATION	Mandatory, Nonrepeatable, Reprocessed	Site ID and location information. Required only for extraction processing.
NO_MISSING	Optional, Repeatable	Identify those AUDIT variables on which to <u>not</u> report occurrences of missing values.
QAOUT	Mandatory, Nonrepeatable	File identifier of quality assessed surface data.
RANGE	Optional, Repeatable, Reprocessed	Set new range checks and missing values for QA of indicated data variables.
XDATES	Mandatory, Nonrepeatable	Inclusive dates to be used for data extraction. Required only for extraction processing; should be omitted for QA.

TABLE A-6

DESCRIPTION OF KEYWORD PARAMETERS FOR THE SURFACE PATHWAY

Keyword	Parameter(s)	
AUDIT	sfname1 ... sfnameN	
where:	sfname1 ... ... sfnameN	Specifies the variables name(s), as defined in Table C.2 of Appendix C, that are to be tracked during the quality assessment
DATA	archive_filename file_format factor [type]	
where:	archive_filename	The name of the file (or tape) containing the archive of hourly surface observations
	file_format	Archive file format: **CD144FB** (for data on diskette) or **3280VB** and **3280FB** (tapes only)
	factor	Specifies the number of logical records in one physical record; for CD144FB diskette this value is 1
	[type]	Specifies the collating sequence: **ASCII** (default) or **EBCDIC**; required only when AERMET is run on an IBM mainframe computer
EXTRACT	extracted_data_filename	
where:	extracted_data_ filename	Specifies the name of the output file for data extracted from an archive data file

TABLE A-6, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE SURFACE PATHWAY

Keyword	Parameter(s)	
LOCATION	site_id lat/long long/lat tadjust	
where:	site_id	Specifies the station identifier for which data are to be extracted
	lat/long	Specifies the station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator or S for sites south of the equator (or W for sites west of Greenwich or E for sites east of Greenwich)
	long/lat	Specifies the station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich or E for sites east of Greenwich (or N for sites north of the equator or S for sites south of the equator)
	tadjust	Specifies the number of time zones west (for a positive value) or east (for a negative value) of Greenwich; for hourly observations, this value is usually 0
NO_MISSING	sfname1 ... sfnameN	
where:	sfname1 ... ... sfnameN	Specifies the variable name(s), as defined in Appendix C, of the hourly surface variables that should be tracked and summarized during the quality assessment, but suppresses writing individual messages to the message file (defined by the ERRORS keyword on the JOB pathway)
QAOUT	qa_output_filename	
where:	qa_output_ filename	Specifies the name of the output file from the QA

TABLE A-6, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE SURFACE PATHWAY

Keyword	Parameter(s)	
RANGE	sfname lower_bound <[=] upper_bound missing_indicator	
where:	sfname	Specifies the variable name, as defined in Table C.2
	lower_bound	Specifies the minimum value of the valid range of values for sfname
	<[=]	Specifies whether to exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA
	upper_bound	Specifies the maximum value of the valid range of values for sfname
	missing_indicator	Specifies the value to use to indicate the value is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Specifies the beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make the keyword statement more readable
	YE/ME/DE	Specifies the ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

TABLE A-7

DESCRIPTION OF ONSITE PATHWAY KEYWORDS

Keyword	Type	Description
ONSITE	Mandatory, Nonrepeatable	Start of ONSITE block.
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variables.
CHARS	Optional, Repeatable, Reprocessed	Define surface characteristics of albedo, Bowen ratio, and surface roughness length (m) by wind direction sector and time period. Defaults: roughness length = 0.25 m, albedo = 0.2, Bowen ratio = 0.2
DATA	Mandatory, Nonrepeatable	Input file name of on-site data.
DELTA_TEMP	Optional, Nonrepeatable, Reprocessed	Define heights (meters) for temperature differences.
FORMAT	Mandatory, Repeatable, Reprocessed	FORTRAN format for reading VARS. Required if a QA file does not exist.
FREQ_SECT	Optional, Repeatable, Reprocessed	Set-up for definitions of surface characteristics, indicating number of wind sectors and time periods. Must precede SECTOR and CHARS statements.
HEIGHT	Optional*, Nonrepeatable, Reprocessed	Define heights of the on-site measurements. * Mandatory if the heights are not in the data file.
LOCATION	Mandatory, Nonrepeatable, Reprocessed	Site ID and location information.
MIN_WIND	Optional, Nonrepeatable, Reprocessed	Set minimum detectable wind speed (meters/second). Default: 1.0 m/s
NO_MISSING	Optional, Nonrepeatable	Identify those AUDIT variables on which to not report occurrences of missing values.

Table A-7, continued

DESCRIPTION OF ONSITE PATHWAY KEYWORDS

Keyword	Type	Description
OBS/HOUR	Optional*, Nonrepeatable	Number of observations each hour. * Mandatory only if the observations are more frequent than once per hour.
QAOUT	Mandatory, Repeatable	File name of quality assessed on-site data.
RANGE	Optional, Repeatable, Reprocessed	Set new range checks and missing values for QA of indicated data variables.
SECTOR	Optional, Repeatable, Reprocessed	Define position of each wind sector in degrees.
VARS	Mandatory, Repeatable, Reprocessed	Define order of variables as they appear in the DATA file. Required if a QA file does not exist.
XDATES	Optional, Nonrepeatable	Inclusive dates for data processing.

TABLE A-8

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
AUDIT	osname1 ... osnameN	
where:	osname1 ... ... osnameN	Specifies the variables name(s), as defined in Table C.3 of Appendix C, that are to be tracked during the quality assessment
CHARS	frequency_index sector_index albedo Bowen roughness	
where:	frequency_index	Specifies the index of the period for which the surface characteristics apply; for **ANNUAL** on FREQ_SECT keyword, valid values: 1 (for the entire year) for **MONTHLY** on FREQ_SECT keyword, valid values: 12 (corresponding to each month of the year) for **SEASONAL** on FREQ_SECT keyword, valid values: 1 = Spring 2 = Summer 3 = Autumn 4 = Winter
	sector_index	Specifies the sector corresponding to the direction from which the wind is blowing
	albedo	Specifies the albedo for the frequency index and sector index specified
	Bowen	Specifies the Bowen ratio for the frequency index and sector index specified
	roughness	Specifies the surface roughness length for the frequency index and sector index specified

TABLE A-8, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
DATA	archive_filename	
where:	archive_filename	The name of the file containing the on-site data
DELTA_TEMP	index lower_height upper_height	
where:	index	Index for the ith temperature difference measurement
	lower_height	Lower measurement height for the ith temperature difference
	upper_height	Upper measurement height for the ith temperature difference
FORMAT	record_index Fortran_format	
where:	record_index	Specifies the record in the data observation that the format refers to.
	Fortran_format	The Fortran format used to read the record
FREQ_SECT	frequency number_of_sectors	
where:	frequency	Specifies how often the surface characteristics change **MONTHLY** - **SEASONAL** - where the seasons are defined as: Spring = March, April, May Summer = June, July, August Autumn = September, October, November Winter = December, January, February **ANNUAL**
	number_of_sectors	Specifies the number of wind direction sectors by which the surface characteristics vary

TABLE A-8, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
HEIGHT	height1 ... heightN	
where:	height1 ... heightN	Specifies the heights of the on-site data measurements; useful if the heights are not in the data file
LOCATION	site_id lat/long long/lat tadjust	
where:	site_id	Specifies the station identifier for which data are to be extracted
	lat/long	Specifies the station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator or S for sites south of the equator (or W for sites west of Greenwich or E for sites east of Greenwich)
	long/lat	Specifies the station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich or E for sites east of Greenwich (or N for sites north of the equator or S for sites south of the equator)
	tadjust	Specifies the number of time zones west (for a positive value) or east (for a negative value) of Greenwich; for hourly observations, this value is usually 0
MIN_WIND	threshold_wind_speed	
where:	threshold_wind_speed	Specifies the minimum detectable wind speed for the on-site measurements
NO_MISSING	osname1 ... osnameN	
where:	osname1 ... osnameN	Specifies the variable name(s), as defined in Appendix C, of the on-site variables that should be tracked and summarized during the quality assessment, but suppresses writing individual messages to the message file (defined by the ERRORS keyword on the JOB pathway)

TABLE A-8, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
OBS/HOUR	n_obs	
where:	n_obs	Specifies the number of time periods per hour the on-site data are reported; for example if the data are recorded every 15 minutes, then n_obs = 4.
QAOUT	qa_output_filename	
where:	qa_output_ filename	Specifies the name of the file where the data are written from the QA
RANGE	osname lower_bound <[=] upper_bound missing_indicator	
where:	osname	Specifies the variable name, as defined in Table C.3
	lower_bound	Specifies the minimum value of the valid range of values for osname
	<[=]	Specifies whether to exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA
	upper_bound	Specifies the maximum value of the valid range of values for sfname
	missing_indicator	Specifies the value to use to indicate the value is missing
SECTOR	sector_index beginning_direction ending_direction	
where:	sector_index	An index that links a specific set of site characteristics to a specific wind sector.
	beginning_ direction	Specifies the beginning wind direction of the sector, and is considered a part of this sector
	ending_direction	Specifies the ending wind direction of the sector, and is NOT considered a part of this sector NOTE: the end of one sector must be the beginning of the next sector

TABLE A-8, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
VARS	record_index osname1 ... osnameN	
where:	record_index	Links the list of variables names on this keyword statement to a Fortran format statement defined on a FORMAT keyword statement
	osname1 ... osnameN	Specifies the list, and order, of variables in the on-site data file that are to be read
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Specifies the beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make the keyword statement more readable
	YE/ME/DE	Specifies the ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

TABLE A-9

DESCRIPTION OF MERGE PATHWAY KEYWORDS

Keyword	Type	Description and Usage
MERGE	Mandatory, Nonrepeatable	Start of MERGE block.
OUTPUT	Mandatory, Nonrepeatable	File identifier for merged data.
XDATES	Optional, Nonrepeatable	Inclusive dates for data processing. If omitted, the earliest date found in the data is used as the beginning date and the ending date is 367 days later.

TABLE A-10

DESCRIPTION OF KEYWORD PARAMETERS FOR THE MERGE PATHWAY

Keyword	Parameter(s)	
OUTPUT	merged_data_filename	
where:	merged_data_ filename	Specifies the name of the output file from STAGE 2
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Specifies the beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make the keyword statement more readable
	YE/ME/DE	Specifies the ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

TABLE A-11

DESCRIPTION OF METPREP PATHWAY KEYWORDS

Keyword	Type	Description and Usage
METPREP	Mandatory, Nonrepeatable	Start of METPREP block.
DATA	Mandatory, Repeatable	Input file identifier of merged data.
LIST	Optional, Nonrepeatable	Flag to print OUTPUT and PROFILE data in the general REPORT file.
LOCATION	Mandatory, Nonrepeatable	Source information. All METPREP processing is performed relative to this location.
METHOD	Mandatory, Repeatable*	Redefine processing methodology used in generating output file for a particular variable.
MODEL	Optional, Nonrepeatable	Name of dispersion model for data are processed. Default: AERMOD
NWS_HGT	Optional, Repeatable	NWS instrument height, in meters, for the specified variable. Default for wind: 10 m
OUTPUT	Mandatory, Nonrepeatable	File identifier for surface output data that will be input to the dispersion model.
PROFILE	Mandatory, Nonrepeatable	File name for the output profile data that will also be input to dispersion model.
TRACE	Optional, Nonrepeatable	Flag enabling more detailed tracing of processing.
XDATES	Optional, Nonrepeatable	Inclusive dates for data processing.

* - At present there is only one processing method defined; therefore, although this keyword is repeatable, it should appear only once in a runstream if the keyword is used.

TABLE A-12

DESCRIPTION OF KEYWORD PARAMETERS FOR THE METPREP PATHWAY

Keyword	Parameter(s)	
DATA	merged_data_filename	
where:	merged_data_filename	The name of the file containing the merged NWS and, if any, on-site data
LIST	<none>	
LOCATION	site_id source_lat/long source_long/lat tadjust	
where:	site_id	Specifies the station identifier for which data are to be extracted
	lat/long	Specifies the latitude (or longitude) of the source; in decimal degrees with the suffix N for sites north of the equator or S for sites south of the equator (or W for sites west of Greenwich or E for sites east of Greenwich)
	long/lat	Specifies the station longitude (or latitude) of the source; in decimal degrees with the suffix W for sites west of Greenwich or E for sites east of Greenwich (or N for sites north of the equator or S for sites south of the equator)
	tadjust	Specifies the number of time zones west (for a positive value) or east (for a negative value) of Greenwich
METHOD	atmos_variable option	
where:	atmos_variable	Identifies the variable that will be processed **WIND_DIR** - process NWS wind directions
	option	Specifies the processing option: **NWS_10** - leaves NWS wind directions to the nearest 10° (default) or **RANDOM** - randomize NWS wind directions
MODEL	model_name	
where:	model_name	Specifies the name of dispersion model the AERMET output is for; allowable names are: **AERMOD**

TABLE A-12, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE METPREP PATHWAY

Keyword	Parameter(s)	
NWS_HGT	variable_name instrument_height	
where:	variable_name	Specifies the weather variable that requires an instrument height to be defined; valid names are: **WIND** (to specify anemometer height)
	instrument_height	Specifies the height of the instrument, in meters
OUTPUT	parameter_filename	
where:	parameter_ filename	Specifies the name of the output file from STAGE 3, with one record per hour
PROFILE	profile_filename	
where:	profile_name	Specifies the name of the output file containing multi-level data
TRACE	<none>	
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Specifies the beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make the keyword statement more readable
	YE/ME/DE	Specifies the ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

APPENDIX B

VARIABLE NAMES AND DEFAULT QA VALUES

This appendix lists the variable names for each type of data and provides a short description of and the units for each variable, and gives the default bounds and missing value codes. This information is presented in the tables that follow, with each table divided into the following fields:

Variable Name

This is the four-character name that can be used on RANGE, AUDIT, and VARS statements. An asterisk (*) indicates that the variable is automatically included in the QA for the path and need not be specified on an AUDIT record in the control file.

Description and Units

A brief description of each variable and the units follow the name. For UPPERAIR and SURFACE, real variables are stored as integers, in which case the units include a multiplier, such as *10 or *100, in order to maintain additional significant digits. For example, if the units are °C*10, then 1.5 °C is stored and referenced as 15.

Type of Check

The type of check determines whether to include (<=) or exclude (<) the lower and upper bounds in the range of acceptable values, and can be changed on a RANGE statement.

Missing Value Code

The missing value code is the value that AERMET interprets to mean that a value is not present. It is also the value written/stored by AERMET when the variable is not present or cannot be calculated.

Bounds

The last two fields are the lower and upper bounds that determine the interval of acceptable values. The value of the variable is accepted if it lies within this interval, where the endpoints are either included or excluded according to the Type of Check. Note that the multiplier, if present, must also be applied to these values.

TABLE B-1

VARIABLE AND QA DEFAULTS FOR THE UPPERAIR VARIABLES

Variable Name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
UAPR	Atmospheric pressure	millibars *10	<	99999	5000	10999
UAHT	Height above ground	meters	<=	-99999	0	5000
UATT	Dry bulb temperature	°C *10	<	-9990	-350	+350
UATD	Dew-point temperature	°C *10	<	-9990	-350	+350
UAWD	Wind direction	degrees from north	<=	999	0	360
UAWS	Wind speed	meters/second *10	<	9990	0	500
UASS	Wind speed shear	(m/s)/(100 meters)	<=	-9999	0	5
UADS	Wind direction shear	degrees/(100 meters)	<=	-9999	0	90
UALR	Temperature lapse rate	°C/(100 meters)	<=	-9999	-2	5
UADD	Dew point deviation	°C/(100 meters)	<=	-9999	0	2

TABLE B-2

VARIABLE AND QA DEFAULTS FOR THE SURFACE VARIABLES

Variable Name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
ALTP	Altimeter pressure	inches of mercury	<=	-9999	2700	3200
SLVP[*†]	Sea level pressure	millibars *10	<	99999	9000	10999
PRES[*]	Station pressure	millibars *10	<	99999	9000	10999
CLHT	Ceiling height	kilometers *10	<=	999	0	300
TSKC[*]	Total//opaque sky cover	tenths//tenths	<=	9999	0	1010
C2C3	2//3 level cloud cover	tenths//tenths	<=	9999	0	1010
CLC1	Sky cond//cover, level 1	------//tenths	<=	999	0	910
CLC2	Sky cond//cover, level 2	------//tenths	<=	999	0	910
CLC3	Sky cond//cover, level 3	------//tenths	<=	999	0	910
CLC4	Sky cond//cover, level 4	------//tenths	<=	999	0	910
CLT1	Cloud type//height, level 1	------//(km *10)	<=	99999	0	98300
CLT2	Cloud type//height, level 2	------//(km *10)	<=	99999	0	98300
CLT3	Cloud type//height, level 3	------//(km *10)	<=	99999	0	98300
CLT4	Cloud type//height, level 4	------//(km *10)	<=	99999	0	98300
PWTH	Present weather (2 types)	------//-----	<=	0	0	9292
HZVS	Horizontal visibility	kilometers *10	<=	99999	0	1640
TMPD[*]	Dry bulb temperature	°C *10	<	999	-300	350
TMPW	Wet bulb temperature	°C *10	<	999	-650	350
DPTP	Dew-point temperature	°C *10	<	999	-650	350
RHUM	Relative humidity	whole percent	<=	999	0	100
WD16[*]	Wind direction	tens of degrees	<=	99	0	36
WIND[*]	Wind speed	meters/second *10	<=	-9999	0	500

* Automatically included in audit report.
† A value < 800 in CD144 files is converted to SLVP/10.0 + 1000.0
// The two variables have been combined to form one variable; the Missing Indicators, and Lower and Upper Bounds have also been concatenated.

TABLE B-3a

VARIABLE AND QA DEFAULTS FOR THE ON-SITE SCALAR AND DATE/TIME VARIABLES

Variable name	Name	Units	Type	Missing Indicator	Lower Bound	Upper Bound
HFLX	Surface heat flux	watts/square meter	<	999	-100	800
USTR	Surface friction velocity	meters/second	<	999	0	2
MHGT	Mixing height	meters	<	9999	0	4000
ZOHT	Surface roughness length	meters	<	999	0	2
SAMT	Snow amount	centimeters	<=	999	0	250
PAMT	Precipitation amount	centimeters	<=	999	0	100
INSO	Insolation	watts/square meter	<	9999	0	1250
NRAD	Net radiation	watts/square meter	<	999	-100	800
DT01	Temperature diff.(U - L)[1]	°C	<	9	-2	5
DT02	Temperature diff.(U - L)[1]	°C	<	9	-2	5
DT03	Temperature diff.(U - L)[1]	°C	<	9	-2	5
US01	User's scalar #1	user's units	<	999	0	100
US02	User's scalar #2	user's units	<	999	0	100
US03	User's scalar #3	user's units	<	999	0	100
ALTP	Altimeter pressure	inches mercury*100	<=	-9999	2700	3200
SLVP*	Sea level pressure	millibars *10	<	-9999	9000	10999
PRES*	Station pressure	millibars *10	<	-9999	9000	10999
CLHT*	Ceiling height	kilometers *10	<=	-9999	0	300
TSKC*	Sky cover (total/opaque)	tenths	<=	99	0	10
OSDY	Day		<=	-9	1	31
OSMO	Month		<=	-9	1	12
OSYR	Year		<=	-9	0	99
OSHR	Hour		<=	-9	0	24
OSMN	Minutes		<=	-9	0	60

[1](U - L) indicates (upper level) - (lower level).

TABLE B-3b

VARIABLE AND QA DEFAULTS FOR THE ON-SITE MULTI-LEVEL VARIABLES

Variable name	Name	Units	Type	Missing Indicator	Lower Bound	Upper Bound
HT*nn*	Height	meters	<	9999	0	4000
SA*nn*	Std. dev. horizontal wind	degrees	<	99	0	35
SE*nn*	Std. dev. vertical wind	degrees	<	99	0	25
SV*nn*	Std. dev. v-comp. of wind	meters/second	<	99	0	3
SW*nn*	Std. dev. w-comp. of wind	meters/second	<	99	0	3
SU*nn*	Std. dev. u-comp. of wind	meters/second	<	99	0	3
TT*nn**	Temperature	°C	<	99	-30	35
WD*nn**	Wind direction	degrees from north	<=	999	0	360
WS*nn**	Wind speed	meters/second	<	999	0	50
VV*nn*	Vertical wind component	meters/second	<	999	0	5
DP*nn*	Dew-point temperature	°C	<	99	-65	35
RH*nn*	Relative humidity	whole percent	<=	999	0	100
V1*nn*	User's vector #1	user's units	<	999	0	100
V2*nn*	User's vector #2	user's units	<	999	0	100
V3*nn*	User's vector #3	user's units	<	999	0	100

nn in variables HT to V3 refers to the level at which the observation was taken; e.g., TT01 is the temperature at the first level and WS02 is wind speed at the second level.

*Automatically included in audit report.

APPENDIX C

DATA FILE FORMATS

This appendix describes the format of the data files created by AERMET. This includes the EXTRACT and QA files of NWS upper air and surface data, the merged file, and the OUTPUT and PROFILE files that will be input to AERMOD. It does not describe the QA file for on-site data since this file is written with the same user-specified format used to read the original on-site file.

The format of the files is given in terms of the FORTRAN READ statements that must be used to input the data for each observation. Variable names shown in capital letters correspond to those given in Appendix B. Variable names shown in lower case italics are "local" variables that do not correspond to any in Appendix B.

C.1 UPPER AIR SOUNDINGS

Each upper air sounding in both the EXTRACT and QA files is composed of two parts: (1) an identifying header record consisting of the year, month, day, hour, and the number of sounding levels; and (2) a sounding record composed of pressure, height above ground level, temperature, dew-point temperature, wind speed, and wind direction, which is repeated for each level.

Upper air header record:

READ( ) *year, month, day, hour, # levels*

FORMAT (1X, 4I2, I5)

where *hour* is expressed in local standard time (LST) and # *levels* is the number of levels in this sounding. If no soundings were extracted or there are no levels to the data, then # *levels* is zero.

Upper air sounding level data (if # *levels* > 0), repeated # *levels* times.

READ( ) UAPR, UAHT, UATT, UATD, UAWD, UAWS
FORMAT (6(1X,I6))

where UAPR	=	atmospheric pressure (millibars), multiplied by 10
UAHT	=	height above ground level (meters)
UATT	=	dry bulb temperature (°C), multiplied by 10
UAWD	=	wind direction (tens of degrees from north)
UAWS	=	wind speed (meters/second), multiplied by 10

All values on the upper air pathway are written as integers. Several of the values were multiplied by 10, as noted above, to retain one significant digit after the decimal point prior to rounding the result to the nearest whole number. The values are divided by 10 prior to any usage in Stage 3.

C.2 SURFACE OBSERVATIONS

Each hourly surface observation in both the EXTRACT and QA files is written as two records. As with the upper air data, all values are reported as integers with several variables multiplied by 10 or 100 to retain significant digits. Several of the variables are two variables combined and stored as one integer value. These are recognized by the // in the variable name and units below.

The first record of a surface observation is written as follows:

READ( ) *year, month, day, hour*, ALTP, SLVP, PRES, CLHT, TSKC, C2C3, CLC1, CLC2, CLC3, CLC4

FORMAT (1X, 4I2, 4(1X,I5), 6(1X,I5.5))

where *hour*	=	hour in LST
ALTP	=	altimeter pressure (inches of mercury), multiplied by 100
SLVP	=	sea level pressure (millibars), multiplied by 10
PRES	=	station pressure (millibars), multiplied by 10
CLHT	=	cloud ceiling height (kilometers), multiplied by 10
TSKC	=	sky cover, total//opaque (tenths//tenths)
C2C3	=	sky cover, 2//3 layers (tenths//tenths)
CLC*n*	=	sky condition//coverage, layer *n* = 1,2,3,4 (- -//tenths)

The second record of a surface observation is written as follows:

READ( ) CLT1, CLT2, CLT3, CLT4, PWTH, HZVS, TMPD, TMPW, DPTP, RHUM, WD16, WIND

FORMAT (8X, 5(1X,I5.5), 7(1X,I5))

where CLT*n*	=	cloud type//height, *n*=1,2,3,4 (- -//kilometers), multiplied by 10
PWTH	=	present weather, liquid//frozen (no units, see codes below)
HZVS	=	horizontal visibility (kilometers), multiplied by 10
TMPD	=	dry bulb temperature (°C), multiplied by 10
TMPW	=	wet bulb temperature (°C), multiplied by 10
DPTP	=	dew-point temperature (°C),, multiplied by 10
RHUM	=	relative humidity (percent)
WD16	=	wind direction (tens of degrees from north)

WIND = wind speed (meters/second), multiplied by 10

All reports of sky conditions (CLC*n*), cloud types or obscuring phenomena (CLT*n*) and present weather (PWTH) are stored using the TD-3280 numeric codes. This requires converting the appropriate variables in CD-144 and SCRAM files as a part of the extraction process. The following tables relate the TD-3280 codes to CD-144/SCRAM codes. The overpunch characters in the CD-144/SCRAM format are represented as both *X/n*, where *n* is an integer, and as an ASCII character. Only weather producing liquid and/or frozen precipitation are reported in the PWTH variable.

TABLE C-1

SKY CONDITIONS

TD-3280	CD-144	Description of Sky Conditions
00	0	clear or less than 0.1 coverage
01	1	thin scattered 0.1 to 0.5 coverage
02	2	scattered 0.1 to 0.5 coverage
03	4	thin broken 0.6 to 0.9 coverage
04	5	broken 0.6 to 0.9 coverage
05	7	thin overcast 1.0 coverage
06	8	overcast 1.0 coverage
07	X or –	obscuration 1.0 coverage
08	blank	partial obscuration <1.0 coverage
09		unknown

TABLE C-2

CLOUD TYPES

TD-3280	CD-144	Description of Cloud Types
00	0	none
11	4	cumulus
12		towering cumulus
13	X/2, K	stratus fractus
14		stratus cumulus lenticular
15	3	stratus cumulus
16	2	stratus
17	X/4, M	cumulus fractus
18	5	cumulonimbus
19	X/5, N	cumulonimbus mammatus
21	6	altostratus
22	X/6, O	nimbostratus
23	7	altocumulus
24		altocumulus lenticular
28	X/7, P	altocumulus castellanus
29		altocumulus mammatus
32	8	cirrus
35		cirrocumulus lenticular
37	9	cirrostratus
39	X/9,R	cirrocumulus

TABLE C-3

OBSCURING PHENOMENA

TD-3280	CD-144	Description of Obscuring Phenomena
01		blowing spray
03		smoke and haze
04		smoke
05		haze
06		dust
07		blowing dust
30		blowing sand
36		blowing snow
44		ground fog
45		fog
48		ice fog
50		drizzle
60		rain
70		snow
76		ice crystals
98	X or -	obscuring phenomena other than fog (prior to 1984)

The code definitions for present weather conditions (PWTH) are presented below. They are divided into nine general categories that are subdivided into specific weather conditions. Dashes in a field indicate that there is no definition for that code. The 8-digit CD-144 format for weather conditions is converted to the 2-digit TD-3280 categories. Up to two different types of weather may be stored in the PWTH variable in AERMET; however, only weather producing liquid (codes 20-39) and/or frozen (codes 40-69) precipitation are retained in the PWTH variable as liquid//frozen precipitation.

TD-3280	CD-144 (col. 24)	Thunderstorm, Tornado, Squall
10	1	thunderstorm - lightning and thunder
11	2	severe thunderstorm - frequent intense lightning and thunder
12	3	report of tornado or water spout
13	5	light squall
14		moderate squall
15		heavy squall
16		water spout
17		funnel cloud
18		tornado
19	0	unknown

TD-3280	CD-144 (col. 25)	Rain, Rain Shower, Freezing Rain
20	1	light rain
21	2	moderate rain
22	3	heavy rain
23	4	light rain showers
24	5	moderate rain showers
25	6	heavy rain showers
26	7	light freezing rain
27	8	moderate freezing rain
28	9	heavy freezing rain
29	0	unknown

TD-3280	CD-144 (col. 26)	Rain Squall, Drizzle, Freezing Drizzle
30		light rain squalls
31		moderate rain squalls
32		heavy rain squalls
33	4	light drizzle
34	5	moderate drizzle
35	6	heavy drizzle
36	7	light freezing drizzle
37	8	moderate freezing drizzle
38	9	heavy freezing drizzle
39	0	unknown

TD-3280	CD-144 (col. 27)	Snow, Snow Pellets, Ice Crystals
40	1	light snow
41	2	moderate snow
42	3	heavy snow
43	4	light snow pellets
44	5	moderate snow pellets
45	6	heavy snow pellets
46		light snow crystals
47	8	moderate snow crystals
48		heavy snow crystals
49	0	unknown

TD-3280	CD-144 (col 28)	Snow Shower, Snow Squalls, Snow Grains
50	1	light snow showers
51	2	moderate snow showers
52	3	heavy snow showers
53		light snow squalls
54		moderate snow squalls
55		heavy snow squalls
56	7	light snow grains
57	8	moderate snow grains
58	9	heavy snow grains
59	0	unknown

TD-3280	CD-144 (col. 29)	Sleet, Sleet Shower, Hail
60		light ice pellet showers
61		moderate ice pellet showers
62		heavy ice pellet showers
63		light hail
64	5	moderate hail
65		heavy hail
66	8	light small hail
67		moderate small hail
68		heavy small hail
69	0	unknown

TD-3280	CD-144 (col. 30)	Fog, Blowing Dust, Blowing Sand
70	1	fog
71	2	ice fog
72	3	ground fog
73	4	blowing dust
74	5	blowing sand
75		heavy fog
76		glaze
77		heavy ice fog
78		heavy ground fog
79	0	unknown

TD-3280	CD-144 (col. 31)	Smoke, Haze, Blowing Snow, Blowing Spray, Dust
80	1	smoke
81	2	haze
82	3	smoke and haze
83	4	dust
84	5	blowing snow
85	6	blowing spray
86		dust storm
87		--
88		--
89		unknown

TD-3280	CD-144 (col. 29)	
90	1	light ice pellets
91	2	moderate ice pellets
92	3	heavy ice pellets
93		--
94		--
95		--
96		--
97		--
98		--
99		unknown

C.3 MERGE OUTPUT

The merged data file contains a block of records that are the cumulative header records of all input files to Stage 2. These records are followed by blocks of records for each day of observations. Each block of records contains a header record identifying how many records there are in the block for each of the three types of data present. Each block is subdivided into three blocks of records, where each sub-block contains all of the observations for that day for a particular type of data.

The records within a block are written with an 8(I8,1X) format, except for the multi-level on-site records that are written with a 6(F14.6,1X) format. The 22 NWS surface variables, plus the date and time, for each hour are split across four records. Also, if there are more than eight scalar or six multi-level variables on a particular VARS statement, then these records will also be divided across more than one record.

Daily Master Header Record

READ( ) *year, month, day, j_day, n_ua, n_sfc, n_os*
FORMAT (7(I8,1X))

where *j_day*	=	the Julian date for *year/month/day*.
n_ua	=	number of NWS upper air observations.
n_sfc	=	number of NWS surface observations.
n_os	=	number of on-site observations.

Upper Air Records

Upper air data are stored in the same order as in upper air extract/QA files (see D.1).

Surface Records

For each hour, there is a header record with the year, month, day and hour followed by three data records. The 22 variables are written in the same order as shown in D.2, with a maximum of 8 variables per record.

On-Site Records

Scalar Variables

These are written in the same order and on multiple records just as they were given on the VARS statements, but using an 8(I8,1x) format instead of that given on the corresponding FORMAT statements.

Multi-level Variables

Like the scalar variables, these are also written in the same order and on multiple records just as they were given on the VARS statements, but using a 6(F14.6,1x) format.

C.4 AERMOD FILES

Two files are produced for input to the AERMOD dispersion model. The surface OUTPUT contains observed and calculated surface variable, one record per hour. The PROFILE file contains the observations made at each level of an on-site tower, or the one level observations taken from NWS data, one record per level per hour. The contents of these files can also be written to the general report by including a LIST statement in the METPREP block.

SURFACE OUTPUT

READ( ) *year, month, day, j_day, hour,* H, u_*, w_*, *VPTG, PBL, SBL,* L, z_o, B_o, r, W_s, W_d, z_{ref} *temp,* z_{temp}

FORMAT (3(I2,1X), I3,1X, I2,1X, F6.1,1X, 2(F6.3,1X), F5.0,1X, F8.1,1X, F5.2,1X, 2(F6.2,1X), F7.2,1X, F5.0, 3(1X,F6.1))

where *j_day* = Julian date

H = sensible heat flux (W/m^2)

u_* = surface friction velocity (m/s)

w_* = convective velocity scale (m/s)

VPTG = vertical potential temperature gradient in the 500 m layer above PBL

PBL = height of planetary boundary layer (m)

SBL = height of stable boundary layer (m) (not used in AERMOD)

L = Monin-Obukhov length (m)

z_o = surface roughness length (m)

B_o = Bowen ratio

r = Albedo

W_s = wind speed (m/s)

W_d = wind direction (degrees)

z_{ref} = reference height for W_s and W_d (m)

temp = temperature (K)

z_{temp} = reference height for *temp* (m)

PROFILE

READ( ) *year, month, day, hour*, height, top, WD*nn*, WS*nn*, TT*nn*, SA*nn*, SW*nn*
FORMAT (4(I2,1X), F6.1,1X, I1,1X, F5.0,1X, F7.2,1X, F7.1, 1X,F6.1, 1X,F7.2)

where	height	=	measurement height (m)
	top	=	1, if this is the last (highest) level for this *hour*, or 0 otherwise
	WD*nn*	=	wind direction at the current level (degrees)
	WS*nn*	=	wind speed at the current level (m/s)
	TT*nn*	=	temperature at the current level (K)
	SA*nn*	=	σ_θ (degrees)
	SW*nn*	=	σ_w (m/s)

APPENDIX D

SUMMARY OF MESSAGES

During the processing of the input statements and data files, AERMET writes messages to the error/message file defined on the ERRORS keyword statement of the JOB pathway. Each message has the form:

n block $a_1n_1n_2$ *ssssss: message*

where

n = Counter

block = Program block name

$a_1n_1n_2$ = Message code

ssssss: = Subroutine name in which the message was generated

message = Description of message code

The counter *n* is either the sequence number of the keyword statement generating the message, zero when irrelevant, the Julian day plus the hour of an observation with a QA violation or the number of observations when processing is completed. If it is a sequence number, it may be relative to either the current runstream file or to the header statements of a file.

The message code is composed of a letter (a_1) and a 2-digit code (n_1n_2). The letter can be one of the following:

E Indicates a fatal error; if the error occurs during processing of keyword statements, the remaining statements are processed for syntax only. If the error occurs during the processing of data, processing ceases for that block and the processing for the next block begins.

W Indicates a potential problem, but depends on the intended purpose of the runstream. Runstream and data processing continues.

I Provides information on the status of the processing; these messages report on the progress of an AERMET run.

Q Indicates a quality assessment violation; a value for a variable was either outside the interval defined by the upper and lower bounds or it was missing.

T Indicates that the user has requested additional messages be printed during data processing. This code is seen only when the TRACE statement on the METPREP pathway is specified.

The 2-digit codes are grouped into general categories corresponding to the processing in Stages 1, 2, and 3. These categories are

00 - 29 Input statement processing, file header and general processing that is applicable to several pathways;
30 - 39 Upper air sounding processing
40 - 49 Surface observation processing
50 - 59 On-site observation processing
60 - 69 Merge processing
60 - 89 Stage 3 processing

These codes only provide an indication of the processing (runstream or data) that was occurring. They cannot completely specify the reason for the message. Further explanation is left to the 40-character message.

D.1 RUNSTREAM AND FILE HEADER PROCESSING, 00 - 29

E00 A required field on a keyword statement is blank.

E01 A nonrepeatable keyword statement has been repeated or the keyword statement is not defined for the block in which it appears.

E02 Error reading a keyword statement in the runstream.

E03 Error decoding a parameter on a keyword statement.

E04 Incomplete or superfluous information on a keyword statement.

E05 A keyword or keyword parameter is in error.

E06 A parameter on a keyword statement is not within bounds, is not known, or does not match any of the valid parameters for this keyword.

E07 Error opening a file or the file name was previously specified for another file that is already open.

E10 A fatal error occurred while attempting to a temporary file.

E11 A pathway failed the check for completeness of the keyword statements.

E12 Processing cannot be completed because a required keyword statement for the specified block is either missing or in error.

E13 The VARS and/or FORMAT statements were not specified for on-site data or there is a discrepancy between the data and the VARS and FORMAT keywords.

E14 The MODEL keyword statement on the METPREP pathway must precede the OUTPUT keyword statement.

E15 The user-defined wind direction sectors do not cover 360°.

E16 The number of VARS keyword statements exceeds the maximum allowed (defined in OSMRDS), or the number of variable names on a single VARS statement exceeds the maximum allowed (defined in OSMDAT).

W06 Value on an input statement may be unreasonable, but processing continues with this value.

W10 A non-fatal error while attempting to write to a temporary file.

W12 An input statement for the block may be missing or in error; this message depends on the processing requested.

W15 Auditing a variable for QA is disabled for the on-site variable specified. The variable appeared on an AUDIT keyword statement but did not appear on any VARS statements.

I03 The end of the file headers has been reached.

I10 No data are to be extracted for specified pathway (no DATA statement present).

I11 No data are to be QA'd for specified pathway (no QAOUT keyword statement or no ONSITE DATA or EXTRACT statements).

I12 No data are to be merged for the specified pathway (no QAOUT statement).

I19 End-of-file encountered on the input runstream file.

E20 Error reading a header record from a file.

E21 Error writing a header record to a file.

E22 End of file reading header records - no data to process.

E23 Error re-reading the header records written to an output file.

E24 The chronological day was not computed correctly from the year, month and day (in SUBR.CHROND); or the year, month and day was not computed correctly from the chronological day (in SUBR.ICHRND).

W22 An end-of-file was encountered while reading the headers on an input file - data will not be processed for this block. This is likely a fatal error but is treated as a nonfatal error so the remainder of the data can be processed.

D.2 UPPER AIR PROCESSING, 30 - 39

Any messages that pertain to the UPPERAIR pathway and issued after the input statements are processed are in this category.

E32 The maximum number of errors allowed reading/decoding the input data has been exceeded. The limit is five errors.

E35 Unexpected end of file reading the upper air sounding data.

E36 Error reading the data.

E37 A sounding height is not in any of the height intervals defined for the upper air audit.

W32 Error reading/decoding the input data, but the maximum number of errors allowed was not exceeded.

W33 Sounding surface height found less than zero - the height was reset to zero.

W38 No soundings were retrieved because no match was found with the station ID specified in the LOCATION statement.

I30 Beginning UPPERAIR data processing.

I31 Automatic data modification for upper air soundings is enabled. See Section 5 for a discussion of these modifications.

I32 No data extracted - check the station identifier and extract dates.

I39 End-of-file was encountered on the input file when expected - a correct condition.

Q34 A vertical gradient cannot be computed at because at least one of the heights are missing.

Q35 The difference between the reported height and recomputed height exceeds 50 meters.

Q36 The heights have not been recomputed due to missing data.

Q37 A lower bound quality assessment violation for the variable indicated.

Q38 An upper bound quality assessment violation for the variable indicated.

Q39 The data value for this period and variable is missing.

D.3 SURFACE OBSERVATIONS PROCESSING, 40 - 49

Any messages that pertain to the SURFACE pathway and issued after the input statements are processed are in this category.

E42 The maximum number of errors allowed reading/decoding the input data has been exceeded. The limit is five errors.

E45 Unexpected end of file reading the hourly surface observations

E46 Error reading the data - check the station identifier and extract dates.

W42 Error reading/decoding the input data, but the maximum number of errors allowed was not exceeded.

W43 Error decoding an over-punch character - the missing value code for that variable will be substituted in the output file.

W44 The element name could not be located among the list of possible names (defined in the array VNAMES) for the TD-3280 data.

W47 The station ID in the data file with a blank character - no data are likely to be extracted.

W48 No hourly observations were retrieved because no match was found with the station ID specified on the LOCATION keyword statement.

I40 Processing of the SURFACE data can begin.

I49 End-of-file was encountered on the input file when expected - a correct condition.

Q47 A lower bound quality assessment violation for the variable indicated.

Q48 An upper bound quality assessment violation for the variable indicated.

Q49 The data value for this period and variable is missing.

D.4 ON-SITE DATA PROCESSING, 50 - 59

Any messages that pertain to the ONSITE pathway and issued after the input statements are processed are in this category.

E50 Error reading an input file header.

E51 Error writing an input file header to the output file.

E52 The maximum number of errors allowed reading/decoding the input data has been exceeded. The limit is five errors.

E53 Error writing data to the output file defined on the QAOUT keyword statement.

E54 The observations are not sequential in time.

E55 The number of observations exceeds the number expected for the hour (by default, 1 or the value specified on the OBS/HOUR keyword statement).

E56 End-of-file on the input data was encountered before a complete observation (block of records) was read.

W52 Error reading/decoding the input data, but the maximum number of errors allowed was not exceeded.

I57 An intra-hour observation violated a quality assessment lower bound for the variable specified.

I58 An intra-hour observation violated a quality assessment upper bound for the variable specified.

I59 An end-of-file was encountered on the input file when expected -- a correct condition.

Q57 A lower bound quality assessment violation for the variable specified (for more than one observation per hour, this check is made after the subhourly values have been averaged).

Q58 An upper bound quality assessment violation for the variable specified (for more than one observation per hour, this check is made after the subhourly values have been averaged).

Q59 The data value for this variable and observation period is missing.

D.5 MERGE PROCESSING, 60 - 69

Any messages pertaining to merging the three data types and issued after the input statements are processed are in this category.

E60 Error computing the chronological day from Julian day and year.

E61 Error computing the Julian day and year from the chronological day.

E62 Error reading the UPPERAIR QA data.

E63 Error reading the SURFACE QA data.

E64 Error reading the ONSITE QA data.

E65 Error writing the ONSITE QA data to the OUTPUT file.

E66 Error processing an input file's headers.

E67 No data to merge as determined by the chronological days in the input files.

I67 No XDATES statement - the beginning chronological day was computed as the earliest available date on the three pathways, and the ending chronological day was computed as the beginning day + 367.

D.6 STAGE 3 PROCESSING, 60 - 89

Any messages that pertain to Stage 3 processing and issued after the input statements are processed are in this category.

E70 Preliminary processing has detected an error, or the input file has no data.

E71 Error reading a file - either the data are not on a 1 - 24 hour clock, or the hour for on-site data is represented by the missing value indicator.

E72 Bad wind sector specified (this is a second check on the wind direction sector).

W70 A parameter value (not a data value) does not appear to be correct.

W71 Missing data - no computations can be made for this hour. NWS surface data are missing and the necessary on-site data, if available, are missing.

W72 No upper air data for this day or other data required for the computation of the planetary boundary layer height are missing; no convective planetary boundary height can be computed for the specified hour.

W73 Site ID in NWS data appears blank. Blocking factor may be in error.

W74 Both cloud cover (NWS) and net radiation (on-site) are missing.

W75 Upper air pressure, temperature or height missing for specified hour.

W76 Calculated or on-site value for incoming solar radiation or net radiation is out of range, or net radiation was negative during the day.

W77 Calculated surface albedo is out of range.

W78 Calculated value for friction velocity and/or heat flux is out of range.

W79 Calculated value for density is suspect.

W80 The height from which on-site data that will be used to estimate the dispersion parameters exceeds a maximum value (100 meters) (see SUBR.SUBST); NWS data will be used if it is available.

W81 Substituted NWS surface wind direction, wind speed and reference height for missing on-site data for the specified hour.

W82 One or more of the following is missing for both NWS and on-site data: surface pressure, wind speed, wind direction, reference height, or temperature. The dispersion parameters cannot be computed for the hour.

W83 Only NWS data are available and one or more of the necessary data to compute the dispersion parameters is missing.

W84 Only NWS data are available and the cloud cover is missing (no on-site data to check for net radiation).

I70 Hour 23 data was swapped in for hour 24 data for NWS surface data.

I79 The end of the processing window, defined by the XDATES statement for the METPREP block, was encountered or, if no window was specified, the end-of-file was encountered

The following is written only if the TRACE statement is present for Stage 3 METPREP processing.

T71 Substituted NWS surface data (1 level) for on-site tower data in PROFILE file.

APPENDIX E

PROCESSING NWS DATA FROM MAGNETIC TAPE

Extracting data from magnetic tape as it pertains to the AERMET command language is discussed in this appendix. This discussion is primarily for users who run AERMET on computer platforms that can access magnetic tape drives, such as Digital Equipment Corporation's VAX computers. There is no attempt to describe the system control language required to mount tapes and assign file names. The user is directed to the appropriate system user's manuals for such information.

The only data that is considered here is the National Weather Service data; no attempt is made to read on-site data directly from magnetic tape. When running AERMET on a computer that can access a magnetic tape drive, the user only needs to be aware of a few changes and additions to the AERMET command language. These modifications have to do with the DATA keyword for the SURFACE and UPPERAIR pathways.

E.1 SURFACE PATHWAY

Recall the syntax of the keyword statement:

Syntax:	DATA *archive_filename file_format factor* [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

where the *archive_filename* is the name of the file and must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive_filename* is 48 characters. For processing data from tape, the *archive_filename* is the "name" of the tape, however that name is specified or defined for the computing platform. For example, the name of the tape on a VAX is defined in the system control language that is used to mount the tape on the tape drive.

An additional data format is accessible when working with magnetic tapes. AERMET can process the TD-3280 format available from NCDC. This format is an element-based format in which the data for an entire day is reported one element (weather variable) at a time. To process NWS hourly surface observations in this format, the parameter 3280VB or 3280FB is specified for the *file_format*. The suffixes VB and FB refer to variable-length and fixed-length block records, respectively. For variable-length data, each logical record contains one station's hourly data values for one meteorological element (weather variable) for as many hourly values as occur in the day. For fixed-length data, each logical record contains one station's hourly data values for on meteorological element for 24 hourly values representing one full day of observations. Specification of this suffix depends on how the data were ordered from NCDC. The data are archived at NCDC in the variable-length format and usually supplied to the user in that format, but the user can request NCDC to supply the data in the fixed-length format.

In addition to the TD-3280 format, AERMET can process the CD-144 data discussed in Sections 2 and 3 if it is received on magnetic tape. The *file_format* for this data format is CD144FB, just as if the data are on disk, where the FB indicates that there is a fixed number of characters per logical record. There is no variable-length block option for the CD-144 data format.

The parameter *factor* defines the number of logical records per physical record (or blocking factor), i.e., the number of logical records to process before reading from the tape again. The specification of this factor depends, in part, on the data request submitted to the NCDC. For the TD-3280 format, this factor is 1. For the CD-144 data format, this factor is usually 10. One logical record contains one hour of surface meteorological observations; therefore, a *factor* of 10 indicates that there are 10 logical records, or 10 hours of data, per physical record. If data on tape from NCDC are used, the blocking factor for the particular data format must be specified correctly for AERMET to properly extract the data from magnetic tape. Otherwise, an error reading the physical record may occur (for a factor that is too large) or there will be skips in the data record (for a factor that is too small).

The *type* refers to whether the data on the tape are ASCII or EBCDIC. The default for this field is ASCII. In this version of AERMET, EBCDIC is not functional; therefore, processing data on an IBM mainframe is not an option.

E.2 UPPERAIR PATHWAY

The syntax for the DATA keyword statement for the UPPERAIR pathway is the same as shown above for the SURFACE pathway. The discussion for the *archive_filename* on the SURFACE pathway applies here as well.

The only upper air data format that AERMET currently processes, whether the data are on diskette or magnetic tape, is the TD-6201 data series. For data on magnetic tape, the data are usually ordered from NCDC as variable-length blocks. To process NWS twice-daily soundings in this format, the *file_format* is specified as 6201VB. Each logical record in the variable-length format contains the upper air observations from one station. Like the TD-3280 format, the user can request that the upper air data be supplied in the fixed-length format, in which case the file format is specified as 6201FB, just as for data on diskette.

For the upper air data, the *factor* defines the number of logical records (soundings) per physical record. As with the SURFACE pathway, this value specifies the number of logical records to process before reading from the tape again. The specification of this factor depends, in part, on the data request submitted to the NCDC.

As for the SURFACE pathway, the *type* refers to whether the data on the tape are ASCII or EBCDIC. The default for this field is ASCII. In this version of AERMET, EBCDIC is not functional; therefore, processing data on an IBM mainframe is not an option.

E.3 DATA ON DISKETTE AND TAPE

There may be occasions when the surface and on-site data are on a personal computer, but the upper air data are on magnetic tape on a mainframe. There are three options to unite these three data types.

One option is to upload the AERMET source code to the second computing platform to process the upper air data. However, there is some PC-specific code (as noted in Section 6) that would require modification. The code has to do with the system data and time and opening files. The user should consult the appropriate user's manual on what changes or additions to make for the specific computing platform. Once the AERMET system is operational, the upper air data can be processed from tape and then downloaded to the user's personal computer where the remaining processing can be performed.

A second option involves the same operation as above - uploading the AERMET source code - as well as uploading the surface and on-site data and processing all the data on the second computing platform.

The third option is the reverse of the first two options - download the upper air data to the personal computer. The first step is to copy the data from the magnetic tape to a file on the second computing platform's mass storage <u>without changing the structure of the data</u>. This file of data can then be downloaded to the user's personal computer. However, the size of the file may be a limitation. The user should first determine how much space is required on a personal computer to store the file before downloading it. Some judicious and very careful editing to remove unnecessary records may be necessary on the second computing platform before downloading. Once on the user's personal computer, the file can be processed just as if the data resided on magnetic tape because the structure of the data has not changed. If the user keeps in mind that the structure is the same whether it is "strung out" on a tape or on a disk file, then there should be no problem processing as if it is on tape. If the user did something to change the structure during the copy process, editing process (if that became necessary) or download process, AERMET may not be able to extract any data.

There is not be a preferred option, and there may be other viable options that have not been explored. The user should choose whichever option is easiest to implement.

APPENDIX F

AERMET ENHANCEMENTS

In this appendix, possible enhancements to the AERMET meteorological preprocessor are discussed. These enhancements include the use of the afternoon sounding to adjust the daytime mixing height estimates, an objective scheme to estimate the Bowen ratio, incorporating the effects of anthropogenic heat flux, and estimates of the urban mixing height.

F.1 DAYTIME MIXING HEIGHT ADJUSTMENTS

The mixing height computation currently in AERMET uses the morning (12Z) sounding and the accumulated sensible heat flux to determine the growth of the convective boundary layer. However, changes in the atmospheric sounding during the daytime hours are not accounted for by this scheme. Half of all of the routine soundings now taken are ignored (i.e., the 00Z soundings). Mixing height predictions in the afternoon would be improved by using the 00Z soundings (in the United States) to adjust the computation of this height based upon the morning sounding.

To implement such an enhancement, it is necessary to devise an objective algorithm to find the height of an elevated inversion in the 00Z sounding. This algorithm should ignore any shallow surface-based inversion that could have recently formed if the sounding is taken near or after the hour of sunset. A search is performed for a height interval over which the potential temperature gradient exceeds a user-specified gradient. The height interval examined should probably span at least three sounding points so that a bad data point does not lead to a false detection of the elevated inversion. A preliminary suggestion for the height interval is 200 meters. The potential temperature gradient that corresponds to an elevated inversion would be expected to be at least as stable as isothermal.

Given that an estimate of the afternoon mixed layer height is available, AERMET would then adjust the estimates obtained from the morning sounding and hourly sensible heat flux estimates. If no determination of the afternoon mixing height from the 00Z sounding can be made, then no adjustment would be made to the calculated values currently provided. Otherwise, the afternoon maximum mixing height (at a time estimated to be at a point 75% of the way between sunrise and sunset) would be assigned to the value obtained from the 00Z sounding, and this value would be persisted until sunset. The adjustment of the mixing heights before the time of the afternoon maximum would then be done linearly, with a zero adjustment at the time of the first upward sensible heat flux in the morning, up to the required adjustment at the time of the afternoon maximum to be consistent with the 00Z sounding. The adjustment would be limited to a factor of two.

F.2 AN OBJECTIVE DETERMINATION OF THE BOWEN RATIO

In this version of AERMET, the user specifies a monthly daytime Bowen ratio, chosen from one of three possible values representing the wet and dry extremes, or a typically normal moisture value. These values are a function of the type of surface cover in the particular sector for that month (see Section 5 for a discussion of wind direction sectors). The "dry" Bowen ratio value represents a moisture deficit condition in which the vegetation is under stress. The "normal" Bowen ratio reflects a condition of average rainfall, with sufficient moisture supplied to the vegetative cover to support normal transpiration rates. The "wet" Bowen ratio condition is one of excessive moisture, leading to extra evaporation from surface wetness in addition to the normal transpiration rates. An assumption is made that in the long run, the loss of water to the atmosphere by evaporation is roughly equal to the precipitation gained, and that the appropriate vegetative cover to maintain this steady state is established. The values for the Bowen ratio are chosen for each month as a function of the type of vegetation and its maturity (e.g., leaves emerging in spring, full maturity in summer, or leaves dropping in autumn).

The specification of just one monthly value for the Bowen ratio results in poor temporal variation. The moisture availability can fluctuate significantly within the month. The revised algorithm described here assumes that AERMET is provided with the three moisture-dependent Bowen ratio values for each month, reflecting extremes from wet to dry. The revised method would select one of the values for each day as being the most appropriate.

This new method for AERMET is based in concept on estimates of the daytime sensible heat flux from standard meteorological measurements made by Holtslag et al. (1980). These authors used a modified Priestly-Taylor (1972) model of the energy budget in which the moisture availability (or the daytime Bowen ratio) was empirically found to be a function of the rainfall in the previous 5 days at Cabauw in the Netherlands. This area features a grass cover of approximately 8 cm in length. In the case of little or no rainfall, evaporation rates were substantially reduced, with a correspondingly high Bowen ratio. During periods of normal rainfall, evaporation rates typical of normal transpiration condition were found.

For AERMET, a decision concerning the choice of a wet, dry, or normal Bowen ratio value is analogous to the choice of a moisture availability value by Holtslag et al. The decision for each day would be based upon the previous five days' precipitation total as compared to an average rainfall for the same five-day period. This average rainfall could be the 30-year average or other appropriate period. Similar to the METPRO (Paine, 1987) technique, a five-day rainfall amount that is at least twice the average will result in a "wet" designation. Rainfall less than half the average will result in a "dry" designation. Amounts of rainfall in between these extremes will earn a "normal" designation. For each day, a new running five-day total precipitation total and average would be computed. The Bowen ratio determined with this method will thus be subject to daily fluctuations. However, the Bowen ratio would be the same value for the entire daytime period for any given day.

The required input data to AERMET would consist of hourly precipitation data (as provided on the Solar and Meteorological Surface Observation Network (SAMSON) data, monthly average precipitation, and the three monthly Bowen ratio values (dry, normal, wet).

F.3 URBAN EFFECTS

AERMET uses an energy balance formulation to determine 1) whether stable or unstable conditions are present, and 2) to quantitatively determine for unstable conditions the surface heat flux and other boundary layer values. A simple formula, appropriate for rural areas, is

$$R_n = Q_h + Q_e + Q_g,$$

where

R_n is the net radiation,

Q_h is the sensible heat flux,

Q_e is the latent heat flux, and

Q_g is the soil heat flux.

To date, Q_g has been parameterized in AERMET as 0.1 R_n (after Holtslag and van Ulden, 1983) and Q_h and Q_e are determined from an estimate of the daytime Bowen Ratio (= Q_h/Q_e). The sign of the net radiation is used to determine the sign of the Monin-Obukhov length. This choice is important in AERMOD due to the selection of dispersion algorithms.

A more general expression for the energy balance accounts for anthropogenic heat flux (Q_a) as well as allowing G to be a variable fraction (c_g) of R_n:

$$R_n + Q_a = Q_h + Q_e + c_g R_n,$$

The flux of heat into the ground during the daytime will be parameterized as a fraction (range: 0 to 1.0) of the net radiation. Holtslag and van Ulden (1983) obtained a value of c_g of 0.1 for a grass covered surface in the Netherlands. Oke (1982) indicates that typical ranges for c_g are 0.05 to 0.25 in rural areas, 0.20 to 0.25 in suburban areas, and 0.25 to 0.30 in urban regions.

The anthropogenic heat flux can be neglected except in highly urbanized locations. Table F-1, taken from Oke (1978), provides estimates for urban areas.

TABLE F-1

AVERAGE ANTHROPOGENIC HEAT FLUX (Q_a) AND NET RADIATION (R_n) FOR SEVERAL URBAN AREAS (FROM OKE, 1978)

Urban area/ latitude/period	Population (x 10^6)	Population density (persons/km^2)	Per capita energy usage (MJx10^3/yr)	Q_a (W/m^2)	R_n (W/m^2)
Manhattan (40°N)					
annual	1.7	28,810	128	117	93
summer				40	
winter				198	
Montreal (45°N)					
annual	1.1	14,102	221	99	52
summer				57	92
winter				153	13
Budapest (47°N)					
annual	1.3	11,500	118	43	46
summer				32	100
winter				51	-8
Sheffield (53°N)					
annual	0.5	10,420	58	19	56
West Berlin (52°N)					
annual	2.3	9,830	67	21	57
Vancouver (49°N)					
annual	0.6	5,360	112	19	57
summer				15	107
winter				23	6
Hong Kong (22°N)					
annual	3.9	3,730	34	4	~110
Singapore (1°N)					
annual	2.1	3,700	25	3	~110
Los Angeles (34°N)					
annual	7.0	2,000	331	21	108
Fairbanks (64°N)					
annual	0.03	810	740	19	18

In addition to the anthropogenic heat flux, the accurate specification of a large surface roughness length appropriate for cities will have the effect of increasing the Monin-Obukhov length to account for the near surface shear effects due to building obstacles.

A TABLE OF ROUGNESS LENGTHS APPROPRIATE FOR URBAN ENVIRONMENT TO BE SUPPLIED

F.4 URBAN MIXING HEIGHTS

For urban areas, the additional heating due to anthropogenic sources creates a higher convective mixed layer during the day. This effect will be accommodated in a future version of AERMET by a higher sensible heat flux input to the modified Carson model. At night (when a negative net radiation is measured or parameterized), a well-mixed layer is observed near the surface over the built-up areas of cities of all sizes. This layer is caused by reduced upward radiation due to the presence of buildings, as well as the anthropogenic heat flux. The depth of the layer is observed to be on the order of 50-100 meters for small cities, 150-200 meters for moderately large cities, and 300-400 meters over large cities. These observations are consistent with a model proposed by Summers (1965):

$$h_{urban} = \{ 2 H_a x / [c_p \rho (d\theta/dz)] \}^{1/2}$$

where H_a is the anthropogenic heat flux,

x is the upwind fetch length over the urban area, $d\theta/dz$ is the vertical potential temperature gradient at the top of the mixed layer.

In a future version of AERMET, H_a and x would be specified by the user as a function of month and (in the case of x) by direction sector. The value of $d\theta/dz$ would be derived from the rural stable θ_* value using boundary layer parameterizations.